1992

User characteristics in intelligent tutoring systems

Michelle Buckenmeyer

Rochester Institute of Technology

School of Computer Science and Technology

User Characteristics In Intelligent Tutoring Systems

by

Michelle Buckenmeyer

A thesis, submitted to

The Faculty of the School of Computer Science and Technology

in partial fulfillment of the requirements for the degree of

Master of Science in Computer Science.

Approved by:

5/20/92

Professor Al Biles — Date

5/20/92

Fr. David Stump — Date

5/20/92

Professor Walter Wolf — Date

PERMISSION TO REPRODUCE THESIS

Title of Thesis: User Characteristics in Intelligent Tutoring Systems

I Michelle Buckenmeyer hereby grant permission to the Wallace Memorial Library, of RIT, to reproduce my thesis in whole or in part. Any reproduction will not be for commercial use or profit.

Date: May 27, 1992

ABSTRACT

The development of individualized educational environments, to facilitate learning for the diverse population of students in today's secondary school system, has become more prevalent with the increased ease of access to computers that many schools are now enjoying. The use of Computer Aided Instruction is becoming more common as a means for individual tutoring.

This thesis explores the problem of individualizing this instruction by analyzing the relationship between preferred teaching methods and computer users' personality types, as defined by the Myers-Briggs type indicator and two other "unscientific" user characteristics. The preferred teaching method was analyzed using various criteria, including user choices, both sequence and quantity, opinion survey, comments, and observation.

The results support many of the conclusions formulated in earlier studies, especially those concerning the independence of performance and the quantity of instruction, as well as the need for multiple instructional methodologies due to type differences. These two conclusions, alone, encourage the idea of more individualized instruction and foster the development of Intelligent Tutoring Systems to provide the student with an environment that is most conducive to his/her learning preference.

DEDICATION

The thesis presented by Kathleen Lambert provided a tremendous starting point for my research study. As my work has been directly affected by her work, I wish to thank her for her great efforts and her encouragement.

My family has provided not only encouragement and support during my years of graduate study but through all my academic endeavors. They have been my guiding beacons when I felt lost, as well as my cheerleaders when the team needed that extra push. In a special way, I must thank my mother for never giving up on me, even when I wanted to, and my sister, Judy, who has been my kindred spirit through these last quarters working on my research.

A special thank you and debt of gratitude to Fr. Dave Stump, whose zest for the unknown and willingness to explore allowed the proposal to become a reality. Along with Al Biles, they made an idea into a viable research study and hopefully usable software. To the young men who "suffered" through that unknown and survived computer science class, my thanks again.

Finally, to my boss and dear friend, Don Porto, I wish to express my utmost appreciation for his help and perserverance when no one was willing to take that first step, for his patience and understanding when the study left me drained and difficult to deal with, and for his support and openness when I needed a compassionate but unbiased ear to help me realize the limits and the possibilities.

You have all been wonderful. I could not have done it without you.

TABLE OF CONTENTS

CHAPTER 1. INTRODUCTION

Prologue

Current trends in education are being directed toward the use of computers in the classroom and Computer-Aided Instruction. Continued research in the development of Intelligent Computer-Aided Instruction or Intelligent Tutoring Systems is becoming paramount in the instructional environment of today´s high school as the demands for more individualized educational opportunities are encountered. Organizations such as EPIC, Educators Promoting Involvement with Computers, are attempting to address these demands at the elementary and secondary school level through their direct work with programs developed for use in the "computer labs" of their schools. (MART89) The key to such programs lies in their ability to work with students on a one-to-one basis. A primary pedagogical concern in most educational environments is the problem of teaching a group of students with varying degrees of ability and receptiveness to different teaching strategies A teaching method effective for one student may be totally ineffective for another; but because of the current design of the typical classroom, multiple methods are not usually available; and the method most easily assimilated by the teacher is the method used. With the use of personal computers in the classroom, the possibility of relieving a portion of the individual instruction problem may be realized. Central to the realization of quality education on a universal basis is the development of individualized instruction that takes into account the great human diversity in cultural background, lifestyles, values, goals, motivation, mental abilities and personality of the student. (HOLT70)

In an effort to better define the needs of the learner in the educational setting influenced by computers, Kathleen Lambert a former graduate student at RIT has studied some of the relationships between the user and the computer through her thesis research. This research has definite implications for the development of more effective human-computer interaction and warrants further study in the ultimate hope of a more usable, individualized student model for computer tutoring and Intelligent Tutoring Systems (ITS) (SKIN68).

<u>Chapter by Chapter</u>

A brief overview of Intelligent Tutoring Systems is presented in Chapter 2. The discussion focusses on the student model and the various directions that the development of ITS designs are going.

Chapter 3 presents a general review of personality typing as delineated by the theories of Isabel Briggs-Myers. Since these personality factors are interpreted to generate Keirsey's Temperament Type groups, a brief description of these groupings is provided. User characteristics for the study are presented in terms of the Myers-Briggs Type Indicators and Keirsey Temperament Types.

Kathleen Lambert's pilot study is the basis for this new research study. Chapter 4 is dedicated to a review of her work; theory, proposal, study description and results.

Chapter 5 presents the details of the current study The ultimate purpose of this work is to lend support to the hypotheses that were tested in the pilot study, concerning student preferences with regards to teaching methods. Differences between the two studies were meant to indicate that some of the limitations of the earlier study were being reduced or eliminated.

The results of the study are discussed in Chapter 6. Data interpretation, statistical analysis and anecdotal observations are presented.

Chapter 7 attempts to realign the presentation, both positively and negatively, by reviewing the limitations of the current study and projecting future directions for similar research.

CHAPTER 2. INTELLIGENT TUTORING SYSTEMS

Computer-Aided Instruction (CAI) environments, considered the foundation for Intelligent Tutoring Systems or Intelligent Computer-Aided Instruction (ICAI) (SKIN68), have long struggled with the problems of material development for the individual using the system, and communication of information in a form that the user can easily assimilate. In the 1960's, William Cooley and Robert Glaser formally recognized one of the most important potential uses of computers in the classroom for individual instruction. They attempted to delineate the major facets of adapting instructional practices to individual requirements: (ATKI69)

1. Educational Goals
2. Individual Capabilities
3. Instructional Means

The factor most changable, individual capabilities, is also the most interesting and the most difficult to quantify, judge and program in the CAI environment. Each person approaches the educational environment with a unique set of aptitudes, goals, motivations and constraints. (HICK74) To this researcher, these individualizing aspects are part of the makeup of a student's personality. These differences impact the pedagogical requirements of the typical classroom. As Alfred Bork noted, "Different students learn in different ways." (BORK81) However, in today's classroom, the student differences are ignored to facilitate the use of a rigidly structured set of learning materials supporting a single path to success (BORK81) or failure. Without a choice in how the education process is completed or even attempted, a student may find it impossible to perform a given task. A study by Hoffman and Waters in 1982 found a tendency in extroverts to drop out of CAI training courses when human interaction was limited, while dropout rates declined when human interactions increased. (CHAM83) Although there are still not enough controlled research studys to formalize a conclusion yet, the implication that a person's internal characteristics will affect how the individual will adapt to and perform using a specific learning methodology is apparent. The ultimate goal in incorporating computers in the "classroom" is to allow each learner to proceed at a different pace and engage in an individual learning experience with educational materials responsive to one's needs. (BORK81) Early CAI developers attempted to produce teaching systems which could adapt to the individual's needs; however, this has proven to be a very difficult task which appears will only be accomplished through research in both Artificial Intelligence and Cognitive Science. (SLEE82)

The problems of understanding how people learn are extremely complex; as most cognitive scientists would acknowledge, current theories of learning are inadequate to explain or predict how the learning process is completed. (KEAR87) Many cognitive psychologists turn to AI for help in understanding problem-solving, learning and intelligence. (BODE89) As Beverly Woolf conjectures, with the advances in AI combined with advances in learning theory, "We are on the verge of developing substantially more powerful tutoring systems that will reason about a student's knowledge, monitor his solutions and custom tailor their teaching strategies to his individual learning pattern." (SELF88) The strengths and weaknesses of these systems are often viewed from the perspective of the student. The flexibility of AI based tutorial programs is greater than traditional CAI programs because they incorporate complex computational models of the student's reasoning to enable them to respond in more adaptive ways which are seen as a greater aid as well as challenge for the student. (BODE89)

Intelligent Tutoring Systems have been developed using three basic concepts as delineated by Clancey; a model of the domain (knowledge base), a model of the student (record keeping---progress) and a model of the communication process (the teacher). (CLAN87) Wenger has extended this structure in terms of four modules; the expert module (domain knowledge), the student module (information receiver), the pedagogical module (communication skills) and the interface module (communication format). (WENG87) The expert module relates directly to Clancey's domain model. However, the remaining modules do not have the same concrete distinctions. For purposes of this study, the student model described by Greg Kearsley represents a counterpoint to the assumption being tested. The student model used in most ICAI is basically qualitative, in which a student's learning is assessed from the analysis of their response (or response pattern) in an effort to make inferences about their conceptions and misconceptions. (KEAR87) This is not a true model of the student, but rather an evaluation. In ITS terms, "student model" and "student diagnostic model" imply continuous assessment and update of the student's task performance information during instruction. (KEAR87) This is in direct contrast to a more personalized model which attempts to incorporate user characteristics, abilities and traits. Existing ICAI systems have ignored many potentially important student variables in the diagnostic and prescriptive process by relying on student responses alone. (KEAR87) Woolf contends that a good computer tutor is one which understands the student (concepts he knows, the strategies he uses and the misconceptions he has), adapting itself to the student's capabilities; thereby providing the main portion of an ICAI system in the form of the student model module consisting of a "picture" of the learner. (SELF88) Kearsley agrees that "a powerful ICAI system should include important learner variables in the student modeling process." Theoretical debate, as well as empirical evidence,suggest individual difference variables provide valuable implications for the design of adaptive instructional systems. (KEAR87) Similarly, Stellan Ohlsson feels the computer sophistication of today can offer the potential for adapting instructional material to the student at a more refined level than previous generations of educational researchers. (LAWL87) Automated, intelligent, individualized instruction may be one of the most interesting and significant applications of AI being developed today. (SCHA84) The key to preparing the student model is individuality based on the internal workings of the user as defined by his characteristics and learning preferences.

CHAPTER 3. DEFINING USER CHARACTERISTICS

A Review of Personality Theory

As stated earlier, the theories of Isabel Briggs-Myers describe patterns which try to explain a person's behavior as delineated in the four dimensions classified by Lawrence (LAWR79)

S/N sensing/intuitive -- describes learning preferences

J/P judging/perceiving -- reveals work habits

E/I extrovert/introvert -- concerned with interests

T/F thinking/feeling -- looks at commitments and values

The following descriptions refer to the characteristics listed in the above classifications (MYER80):

Sensing -- prefers using the five senses to gain knowledge. An orderly, step-by-step process with practical results is most fruitful learning experience. Wants standard procedure to solve problems rather than theoretical approach.

Intuitive -- prefers imaginative problem solving. Learning is obtained in leaps through an understanding of the combination of facts. Enjoys theories, ideas and using new skills.

Judging -- likes to have a plan before beginning a task and needs closure for that task. Wanting to settle things may force a hurried decision.

Perceiving -- likes to stay flexible and ready for the unexpected. Trying to miss nothing may lead to never finishing a task.

Extrovert -- interested in the outer world of people and things. Action oriented, outward attention.

Introvert -- interested in the inner world of concepts and ideas. Reflective, wants to understand life before living it.

Thinking -- uses logical process to reach conclusions. The goal is an impersonal finding.

Feeling -- uses an appreciation of the situation to reach conclusions. Decision determined by placing a personal, subjective value on it.

The first type dimension describing learning preferences reveals an interesting correlation shown in the following table (HOFF81):

Count	Subjects	Sensing	Intuitive
71	Rhodes scholars	7%	93%
671	National Merit Scholarship finalists	17%	83%
3676	Ivy league college freshmen	41%	59%
3503	College prep juniors/seniors	58%	42%
1430	Non-college prep jrs./srs.	85%	15%
500	Adults not completing grade 8	99.6%	4%

The current teaching methodologies as well as evaluation techniques used in the typical classroom provide an interesting explanation for the success or failure of the student population, according to Lawrence. Students typed as intuitive introverts (NI) make up less than 10% of the average classroom. However, the most common teaching method (lecture and notes) tends to favor the NI student considerably. The individuals who develop the majority of the material used in the typical classroom tend to be NI types as well. (LAWR79)

Temperament Theory

In an effort to develop a connection between temperament theory and personality types, Keirsey combined the preferences reflected in the sixteen Myers-Briggs classifications. Temperament as defined in Webster's Dictionary is "characteristic or habitual inclination or mode of response."(WEBS76) Therefore, consistency in approach and response to situations determines temperament. The four temperaments generated from Keirsey's combinations are presented below with the characteristics of each type. (KEIR78) (LAMB88)

NT: intuitive thinker -- ENTJ, INTJ, ENTP, INTP

NF: intuitive feeler -- ENFJ, INFJ, ENFP, INFP

SP: sensing perceiver -- ESTP, ISTP, ESFP, ISFP

SJ: sensing judicious -- ESTJ, ISTJ, ESFJ, ISFJ

	INTUITIVE THINKER	SENSING PERCEIVER
a)	wants to know	wants spontaneity
b)	competence	freedom to choose action
c)	knowledge	impulses
d)	power over nature	action
e)	intelligence	grace
f)	visionary	negotiator
g)	knowing is most important	doing is most important

	INTUITIVE FEELER	SENSING JUDICIOUS
a)	wants to grow	wants a place
b)	meaning and significance	membership
c)	guide others	responsibility
d)	make a better world	accountability
e)	self-realization	duty
f)	catalyst	traditionalist
g)	becoming is most important	serving is most important

Alan Brownsword summarized Keirsey's work as follows: (BROW87)

> NTs see possibilities and look for meanings and relationships. They think about ideas, concepts, theories and abstractions. Things should make logical sense and knowing why is important. This type of student is curious, independent and challenging. Abstract principles guide their decision-making and their quest for knowledge is never

satisfied.

NFs see the world in terms of possibilities, relationships, connections and meaning. Decisions are based on values, and actions are precipitated by what is important to this individual. They are not good with detail or routine, but grasp abstractions and see interconnections quickly.

SPs excel in crisis situations. They focus on the concrete and practical and deal well with facts and realities. Focussing on the concrete tends to cause problems distinguishing patterns and generalizing from them. These individuals prefer action and thus learn by doing. They need to see the practical use for what they study.

SJs are good with detail. Planning, schedules and follow through help them obtain closure. Dependability, stability and consistency are typical of these individuals. They are not theory oriented nor do they think long range. This student seeks specific direction and guidance from teachers.

These temperament types depict observed patterns of behavior which are so deeply imbedded in a person's makeup, they are not expected to change over time. (KEIR78)

CHAPTER 4. BEFORE THE STUDY

The Proposal

In my efforts to extend Kathy's thesis, I have attempted to further investigate the relationship between user characteristics as defined by personality traits and developing a more effective strategy for intelligent tutoring systems. My research focusses on user characteristics illuminated by given personality factors and the underlying strategies of developing the student model component of intelligent tutoring systems rather than user interface concepts, although both are key issues in the development of intelligent tutoring systems. The research study attempts to eliminate or at least diminish some of the problems and biases encountered in Kathy's experimental study To better understand these problems, a summary of Kathy's work is appropriate.

Summary of the Pilot

Kathleen Lambert's thesis entitled "The Relationship Between Computer Interaction and Individual User Characteristics" explores the problems faced by User Interface (UI) and Computer-Aided Instruction (CAI) designers when developing an effective computer user model. (LAMB88, SKIN68) As Kathy points out, both CAI and UI designers are searching for an optimal model. The thesis proposes that each group is looking for the same user model and that a single, universal model is not sufficient to meet the needs of each individual user. (LAMB88) A study was conducted to demonstrate the inadequacy of a single model and

> . . . to analyze whether user choices in a CAI environment and personality types as defined by the Myers-Briggs type indicator are related strongly enough to provide the basis of future models. (LAMB88)

In this study, the subjects (students) were given control of the order, format and quantity of instruction they used to cover the given material provided in the computer lab. "It was expected that, given the choice, user preferences will be made according to established personality types." (LAMB88)

Kathy discusses the user interface design obstacle of a limited understanding of human behavior as well as the correspon-ding problem of a limited student model due to the situational constraints of teaching a group of individuals, where individualism is key. In this discourse, the problems encountered in User Interface Design are enumerated based on previous studies by Benbasat, VanDerVeer, and Mason and Mitroff. (BENB81, VAND85, MASO73) VanDerVeer's studies demonstrated the importance of cognitive styles and personality factors in problem solving behavior, while Mason and Mitroff pointed up the individualistic aspect of appropriate information for one user not necessarily being useful to another. (VAND85, MASO73) The description of the user model is further delineated along three dimensions by Rich.

1. Single Model vs Collection of Models
2. Designer Models vs. System-inferred Models
3. Models based on long-term vs. short-term user characteristics. (RICH83)

The single user model would force all users to conform to one type of information presentation rather than allow the user access to the most effective means of gaining knowledge (MASO73)

To provide accessibility to the most effective knowledge acquisition method would require at least a minimum set of models differentiated by specific personality variables. (LAMB88)

The major criticism of designer specified models is the fact that the resulting system contains no knowledge of the individual user environment or task characteristics (LAMB88) A system-inferred model would be geared toward an individual's characteristics and interactions.

Both long and short-term models require knowledge of individual user characteristics' importance and interpretation. Rich suggests a model based on stereotypes and clusters of traits which can be further individualized for frequent users of a system. (RICH83) The important issues in each of these dimensions appear to revolve around individualizing the system based on user characteristics, in particular personality traits.

Following this discussion, the related problems in Computer-Aided Instruction as an answer to the question of individualized instruction are presented. Educators and psychologists have argued that a single teaching strategy or method will invariably miss the target for some group of students. (PAPE80, MYER80) One of the earliest goals of CAI was to provide a learning environment that would appeal to each student's unique style (SLEE82) However as Kearsley points out, there has not been great progress in developing sophisticated individualization strategies. (KEAR83) Intelligent CAI systems appear to view the student model as an information processing causal model where behavior is seen as a collection of rules based on the student's visible knowledge of the domain. (SLEE82) While ICAI programs have shown adaptability, they still are plagued by certain short-comings as described by Sleeman and Brown: (SLEE82)

1. Instructional material produced in response to a student's query or mistake is often at the wrong level of detail.

2. Most tutoring systems are capable of solving problems in only one or two prescribed ways. The system coerces the user's performance to fit its own framework.

3 Tutoring and critiquing strategies are excessively ad hoc.

4. User interaction is very restrictive, which limits the user's ability to express an answer, which in turn limits the system's ability to diagnose a problem or misunderstanding.

Kearsley agrees that a better basis in learning and an understanding of how people learn is needed to produce a more effective student model for use in Intelligent Tutoring Systems. (KEAR87) An expansion of the student model based not only on what s/he knows but also on the most effective instructional strategy for that student is required. (LAMB88) How to determine what that strategy may be is a goal of not only UI and CAI developers but psychologists and educators as well.

An individual's preference of learning strategy or cognitive style is believed to influence his/her selection among alternative actions. (MASO73) Scott Diceman explored the relationship between personality and certain aspects of cognitive functioning, theorizing the association between a personality trait and a mode of information processing might indicate the same psychological processes being measured in different ways with different labels. (DICE85) The theory of personality developed by Isabel Briggs-

Myers provides a basis for understanding similarities and differences in human behavior based on Carl G. Jung's work with psychological typing. (MYER80) Learning preferences are included with the personality types which help explain the reasoning behind one student's ability to readily gain certain knowledge, while another student has difficulty or is not interested. (LAWR79) The theories of Isabel Briggs-Myers describe patterns in learning preferences, work habits, interests and values, where one of two choices (considered poles) in each of the four dimensions of "mental behavior" is preferred by an individual. A classification of an individual by a combination of the four dimensions results from being more inclined toward a behavior in each category. Myers-Briggs typing tends to form natural differences in learning styles. (LAMB88) Kathy proceeds to supply descriptions for each dimension and each choice within the dimension, followed by data showing the correlation between type and learning provided by Hoffman and Betkowski. (HOFF81) A discussion of Myers-Briggs personality type indicators and their significance in the teaching/learning environment is pursued as the support for their use in Kathy's study. A more detailed review of this material is presented in chapter 3.

Kathy's Study

A CAI program was developed for one unit of instruction on three programming constructs to test the hypothesis that different formats of information learning would be preferred by established behavioral types. (LAMB88) Six instructional strategies were available for each construct.

Course: Survey of Computer Science at RIT

Hardware: Apple IIe

Software: Apple Pascal using turtlegraphics

Constructs: Loops -- repeat, while, for

Methodology: Menu-based presentation.
Student controlled order, quantity and method of instruction.
Six methods for each construct:
1. Theory-oriented description.
2. Practical description.
3. Graphical explanation.
4. Textual explanation.
5. Examples of usage.
6. Examples of program code.

Personality Typing: 32 question Personality Style Inventory (Hogan & Champagne)
Sufficient correlation to Myers-Briggs Personality Indicators.
On-line administration prior to instruction.
Ten minutes to administer.

Evaluation: Quiz (for extra credit).
Two different formats provided.
Administered by lab proctors.

Study Population: 68 students; 42 male, 26 female.
Various majors and year of study.
Primarily non-technical.

The results of the quizzes, the student's major, gender and year of study were analyzed against the student's personality type and choice of instruction with respect to the following hypotheses: (LAMB88)

1. Different formats of the same information are preferred by different personality types.

2. The amount of information desired varies among individual users.

3 Type of instruction preferred does not correlate to student's major, year of study, sex or quiz score.

Statistical analysis using chi-square distributions was performed and each of the three hypotheses was tested. However, significant results were only found in certain areas. Certain limitations delineated by Kathy would be reasonable explanations for these results.

1. User experience was neither determined nor controlled.

2. Amount of help provided to students in other forms was not controlled.

3. Due to the simple nature of the interface, information the student could provide about himself/herself was limited.

4. Both hardware and software limited the power of the program developed.

5. The small number of subjects.

6. Restricted personality questionnaire which provided complete typing in only 24 subjects

7. Short-term nature of the study. (One unit)

8 All formats were designed and written by one person with his/her own personality type.

Kathy summarized her conclusions as follows: (LAMB88)

1. Varying formats of the same information are differentially useful to different individuals, demonstrating the need for multiple user models

2. The amount of information desired will vary among individual users, which argues against fixed instructional strategies.

3. Increasing the amount of information to a user does not necessarily result in better performance.

4. Removing speed restrictions allows sensing individuals to perform at the level of their intuitive counterparts

I believe Kathy's study has provided sufficient evidence to support the continuance of research in the area of the relationship between personality traits and user characteristics as primary to the development of an effective, learner/student model with regard to intelligent tutoring systems.

CHAPTER 5. THE STUDY

In Search of a Home

In pursuing the answers to several questions about the possibilities, advantages and viability of Intelligent Tutoring Systems, the problems and liabilities of developing a new method of presenting material to students has become quite evident to this researcher. The positive expectations of an innovative and individualized forum for learning have been overshadowed by the restrictive and sometimes unmoving environment of the existing educational system. However, the future of ITS is brightening due to the growing number of educators willing to support and invest in the idea of the individual controlling the method of learning based on one's needs and preferences.

A Chronology of Disappointment

Initial attempts at finding a host institution for the specified study were met with encouragement for the idea but suspicion of the implementation.

With my previous experience in secondary education and my goal of permanent certification in secondary education, the decision to explore Computer Aided Instruction in a Junior or Senior High School environment was appropriate. On May 1, 1989, I contacted Mr. David Dunn, Math Department Chairman and former colleague at Martha Brown Jr. High in Fairport, N.Y., concerning the possibility of using the computer classes at the school for the study. Unfortunately, the computer program had been transferred almost completely to the high school. Since my original intent was to emulate the Apple LOGO system used by Ms. Lambert for comparison purposes, I inquired as to its use there and was informed that the high school did not use that system.

Through my employer, Mr. Donald Porto, my next contact was made with Dr. Leon Foster, Computer Director at Bay Trail Middle School in Penfield, N.Y. on May 11, 1989. Dr. Foster's first impressions of the concept were positive. A copy of the outlined proposal was presented to him with no immediate barriers forthcoming. The middle school computer classes were already using Apple LOGO with turtlegraphics. The estimated student population for the study was set at 400. Appropriate school administrators were informed of the proposal and no conflicts were reported. Meetings with involved faculty were delayed until the end of the school year for administrative reasons. A meeting was held with these faculty members on June 27, 1989. The proposal was presented and was immediately met with anxiety over loss of control and negativism about effectiveness and accountability. All attempts on my part, as well as Dr Foster, to allay their fears and provide sufficient reason to at least discuss the potential benefits of the project were for naught. However, each educator present was interested or at least curious about the outcome of such a study.

My search began anew for that elusive host school Again through the support of my employer, I was introduced to Mr. Joseph Clement, Superintendent of Schools in Spencerport, N.Y. A copy of a modified proposal was presented to Mr Clement after our initial meeting on July 14, 1989. He assured me that copies would be distributed to appropriate faculty and administrators upon his return from vacation at the end of the month. I received a letter from Mr. Clement on July 28, indicating that copies had been sent to Mr. Edward Przybycien, Principal at Cosgrove Jr. High and Dr. Selander, Principal at Spencerport High School. Several follow-up phone calls were placed in the next month and a half, with little or no response from either party. At the end of August, an inquiry from Dr. Selander indicated that he did not have access to the proposal and requested a copy be sent to him immediately. Another copy was presented to him on August 28, 1989. Letters of inquiry were sent to both administrators in September in hopes of garnering a response, for or against the proposal. A formal letter of rejection was received on October 15, 1989. Based on the lack of interest encountered in my phone calls and letters to the schools, I had already begun a new search.

A Glimmer of Hope

One final suggestion from my boss, Mr. Porto, directed me to Fr. David Stump, SJ, Director of Computer Resources at McQuaid Jesuit High School in Rochester, N.Y. On October 10, 1989, I phoned Fr. Stump to present the idea of Intelligent Tutoring Systems and the possibility of a research study involving the computer classes at McQuaid. His initial reaction was very positive and a meeting was scheduled for October 19, 1989. A newly modified proposal was presented. Two more meetings were scheduled in November to investigate the possibilities and requirements for the study on TRS-80 Model IV machines running DOS with TRS-80 BASIC as the implementation language No overwhelming barriers were encountered. A subsequent meeting was held on December 18 with Fr. Stump, Mr. Al Biles, Professor of Computer Science at the Rochester Institute of Technology (thesis advisor) and myself, to discuss concerns and requirements. Delineation and separation of program development by method was mutually agreed upon by all three developers, and all indicators were positive. Each developer worked independently on the instructional material presentations for their particular methodology; text, graphics and examples, based on the class textbook and computer manual supplied by Fr. Stump. Several independent meetings were held throughout January and February of 1990. After months of rejection and tepidity, the classroom implementation commenced on February 26, 1990 amidst high expectations and anticipatory anxiety.

<u>Research Study Implementation</u>

Contacts: Fr. David Stump, Course Developer
Director of Computer Resources
McQuaid Jesuit High School, Rochester

Fr. William McCusker, Guidance Counselor
McQuaid Jesuit High School, Rochester

Mr. Frank Kamp, Assistant Principal
McQuaid Jesuit High School, Rochester

Appropriate Administractive Personnel
McQuaid Jesuit High School, Rochester

Professor J Al Biles, Course Developer/Advisor
Rochester Institute of Technology, Rochester

Course: Basic Computer Instruction

Population: 34 male Sr. High School students enrolled in computer classes at McQuaid High School

Timeframe: Maximum one period per day, five days per week for a given marking period over the course of two marking periods. Starting date: 2/90. Completion date: 4/90.

Hardware: TRS-80 Model IV with 5 1/4" diskettes.

Software: TRS-80 BASIC. Programs developed in concert with appropriate faculty including evaluation measures.

Constructs: Three distinct instructional units.
Input/Output--READ, DATA, RESTORE, PRINT USING
Arrays--One dimensional
String Functions--LEN,STR$,LEFT$,RIGHT$,MID$
Concatenation

Methodology: Instructional methods developed by multiple designers categorized according to personality traits correlated to user characteristics for appropriate typing and evaluation based on user choice of technique or strategy. Menu-Based presentation.

Four methods for each construct:

1. Text Explanation.
2. Definitions.
3. Graphical Representation.
4. Code Examples.

Appendix G provides sample presentations.

Student controlled order, quantity and method of instruction within a unit.
User selections and quiz results recorded on individual diskettes coded by student ID and password for confidentiality.

Personality Typing: Myers-Briggs Type Indicator Survey--Form G administered by Fr. McCusker with results recorded on individual diskettes for each student. Appendix A provided by CPP demonstrates the format of the survey. (CONS87)

Evaluation: On-line quiz with randomly generated quiz questions presented at the completion of a given unit. Lab assignments. On-line survey of prior computer use and experience. One-to one discussions with individuals. Personal observations during the course of the study. Closing Survey and student comments.

Results: Expected development of usable Computer Tutoring System. Research to support the relationship of user characteristics to Intelligent CAI.

The Nuts and Bolts

As mentioned earlier, material for each construct was developed by different individuals with different personality types as indicated in Appendix I. For purposes of the study methods 1 and 2 (Text Explanation and Definitions) were developed by the same individual under the category of text. The choice of methodology to developer was mutually agreed upon by all three developers and appeared to be representative of personal preferences for pedagogical style. At the time class material development began, the Myers-Briggs Personality Type Indicator (MBTI) (CONS87) was not yet available for use by the developers. Also since personnel resources were limited, MBTI results may not have been explicit deciding factors in choice of method designed. The developers were requested to submit their lesson material by construct in written or computer generated form, in the way they would expect the lesson to be presented to the student on the computer. Appendix G provides examples of the material as the student would have seen it displayed (with commentary as necessary for the graphical presentation section) Each developer was also requested to produce a pool of 15 to 20 multiple choice questions per construct to be used in developing the evaluation quizzes for each instructional unit. Sample questions from each developer are provided in Appendix H. One anomaly in this scenario occurred because of a lack of familiarity with the BASIC language string functions in the third unit. The syntax and use of these functions was foreign to the "examples" developer. Therefore, the examples methodology and quiz questions for the string functions unit were developed jointly by the two remaining designers.

The lessons were transferred to a personal computer where they were reformatted using BASIC as the "programming" language to present the material via menus and simple display screens. Once the lesson was in this format, a file transfer utility available on the PC was used to download the implementation programs to the TRS-80. A copy of this application software was placed on twenty 5 1/4" diskettes via the TRS-80 machines.

Each student was provided with another, personal, 5 1/4" numbered floppy diskette used to record the instructional method(s) chosen, the sequence in which they were viewed and the number of times a particular method was viewed (See Appendix L). The student had a login name and numerical ID associated with their diskette. All response/data files for a student were encoded by numerical ID. Diskettes remained in the computer lab at all times to prevent inadvertent data destruction or disk loss. The class was divided into 2 arbitrary groups of 17 by the instructor to accommodate the 20 available machines. The groups are referenced by the letters A and B in the remainder of this work (See Appendix P for the actual breakdown). One group would be in the computer room with the observer working on a unit of instruction while the other group was in the classroom engaged in lecture concerning a different lesson. Students were asked to work independently. The observer was allowed to answer technical questions but was to avoid content questions. Note taking was allowed and students were urged to continue their normal reliance on notes. The class period in the lab was spent totally on the computers reviewing material for the specified lesson.

When a student indicated he was ready to take the quiz for that unit by requesting a quiz diskette, the observer would load the quiz diskette and initiate execution by a control sequence known only to the observer and the instructor to prevent user tampering, as the quiz for a specific unit could only be taken once. All quiz disks contained the same pool of multiple-choice questions by topic along with a quiz producer program that randomly generated question numbers referring to the pool. The quiz was given on-line and the results stored on the student's personal diskette for later retrieval and scoring. No hard copies of the quiz questions were made available until all students had taken the quiz for a given unit. The students were allowed to use scratch paper during the quiz. Because the question numbers for a given quiz were randomly generated, no two quizzes were the same, much to the consternation of a few wandering eyes. The students were allowed to review material in a previous unit after the quiz was completed, but the choices made were not considered in the statistics used for the study.

To provide some continuity, a group spent two consecutive days in the lab and then alternated two days in lecture, two days in the lab, two lecture, etc. Upon completing the quiz for a given unit, a programming "project" on the material for the unit was assigned. Students were expected to work independently on these projects. An attempt was made to keep the two groups synchronized by providing a "make-up" day for any students from either group to complete work on a given unit. Students were also allowed to use the lab during free periods and after school when the lab was "manned" by the observer or the instructor.

Upon completion of the study, all diskettes were collected and all individual student data files were combined into class master files for each topic's responses, quiz questions and answers, use survey results and Myers-Briggs scores, with records keyed on the numerical security code assigned by the student at the initial login. A number from 1 to 34 was arbitrarily assigned to each of the security codes. This is the student number reflected in all student data appendices.

A method opinion (helpfulness) survey was conducted at the conclusion of the research study asking each student to first rate the four methods presented in terms of their helpfulness to the individual on a scale from 1 (useless to me) to 10 (very helpful to me.) Secondly, the students were asked to rate three schemes for future lesson plans from 1 (would be very hard for me) to 10 (would be very helpful to me.) The three schemes listed were textbook presentation alone, machine presentation alone and the combination of text and machine presentation (See Appendix F).

<u>In The Beginning</u>

Upon first access to the personal diskette, a brief introduction of the study is displayed, relating the purpose and content of the program (See Appendix C) The user is then prompted for a login name and a numeric security code (password). These are verified and become the permanent access codes for the diskette. Thereafter, these prompts occur each time the computer is booted with the diskette, and the main program is loaded into the system. All data files (response, survey, personality type) are initialized and encoded with the numeric password supplied by the user. The first access also causes the COMPUTER USE SURVEY to be presented. (See Appendix B) The results are stored on the diskette and the survey will not be repeated once completed. The user is then asked if he is ready to enter the scores from his Myers-Briggs Type Indicator (MBTI) Form. If affirmative, the user is asked to enter the number derived for each of the eight categories of the MBTI. Until this information has been provided, the user will be prompted as to its completion at the beginning of each computer session.

The Myers-Briggs Type Indicator Form G presents questions in two formats as indicated in Appendix A. The answer sheet is divided into four columns as are the questions. Each column corresponds to one of the four personality factors. The questions and therefore the answers are numbered horizontally on the sheets Part I and Part II questions are intermixed but easily distinguished by format (See Appendix A). This version of the survey contained 49 Part I questions and 45 Part II questions. The answer sheet is a carbonized form which records the respondents´ selections and places a point value on each choice. When the survey is complete, the second sheet containing the point values is totalled column-wise (two values for each column). At the bottom of each column, the two values are compared and a tendency in each personality factor is recorded

The PROGRAM

The main menu is presented as follows:

USER MENU

1. INPUT/OUTPUT
2. ARRAYS
3. STRINGS
4. HELP
5. EXIT

Please Enter Your Choice (1-5):

A student must review the topic material in the sequence indicated by the menu number (1-3), as certain material builds on other material. A student may not go on to the next topic until the current topic has been finished, as indicated by the completion of a quiz for that unit. The underlying software guarantees adherence to these conditions. The student may go back to a previous unit after completing the quiz for that unit, but this information is not recorded for analysis purposes.

Within each of the topics, the following menu of methods is provided:

Topic Title

1. Textual Explanation of ...
2. Definitions
3. Graphical Representation of
4. Code Examples of ...
5. HELP
6. QUIZ
7. EXIT

Please Enter Your Choice (1-7):

The user may choose any or all of the methods as many times and in whatever order he feels will be most beneficial. Each choice the user makes is recorded in the response file. After completing the entire presentation for a particular method, the topic menu is redisplayed and the user may make another choice of method, ask for help, exit the program or take the on-line quiz. If the choice is option 5, a very brief explanation of each method is displayed along with a reminder concerning the independence of methods and quiz requirements (See Appendix D). If the user chooses the quiz option, the program is temporarily suspended and the user is directed to ask the observer for a quiz diskette. The quiz diskette is loaded as indicated earlier and a brief statement of instruction is displayed (See Appendix E) A list of questions is generated from the question pool and presented to the user one at a time. The user is given the option to answer the question or go on to the next question. Any questions that are passed will be redisplayed at the end, until all questions have been answered. At the completion of the quiz, program execution is suspended. The user is directed to inform the observer, at which time the quiz disk is removed and the main program is restarted.

Analysis of Data

Both objective and subjective data were obtained for each student.

Objective:
- personality type
- instructional choices by unit
- frequency of instructional choice by unit
- total displays viewed by unit
- quiz grades for each unit
- semester grades
- final course grade

Subjective:
- prior computer experience
- game vs. non-game player
- vocal vs non-vocal student
- methodology usefulness opinion
- format(s) usefulness opinion

The following hypotheses were used as the springboard for the data analysis.

1. Different temperament types and, therefore, different personality types prefer learning using different formats of the same information.

2. The preferred method of instruction does not correlate to prior computer experience, grades or quiz scores.

3. Vocal game players vs. non-vocal non-game players are expected to show a preference for a methodology and should fall into certain temperament types relating to hypothesis 1.

4. Student opinions about presentations after completion are expected to relate to preference. Temperament will then relate to method preference.

Preference for a methodology was based on the instructional choices made and the subjective usefulness survey completed at the end of the research study (See Appendix O). Prior computer experience was judged based on a pre-study survey completed by each student (See Appendix J).

As in Kathy's study, differences in choices made by individuals were expected to demonstrate that no one single method of instruction is right for all students. Certain personality types were expected to prefer certain formats. The amount of information requested was also expected to relate to the individual's personality type. One particular type may need to view all formats several times, whereas another type may require a single format viewed only once. The fact that a student viewed more information was not expected to produce a higher quiz score.

The determination of vocal vs. non-vocal students was expected to show some correlation to personality type and, indirectly, preferred methodology. Those students who need a discussion atmosphere for learning would be expected to gravitate toward a format that would appear more active and interactive. A similar distinction of preference was expected between computer game players and non-game players.

The results of the analysis along with personal observations were expected to support the idea that no one teaching methodology is appropriate for all students, and that the development of individualized instruction should be based on the expectation that differing personality types benefit from different formats of presentation. The proposition that Intelligent Tutoring Systems can be designed to meet individual needs based on the dimensions of personality provides for a more relevant and hopefully productive tutoring environment.

CHAPTER 6. RESULTS

"Bare Bones"

A total of 34 male students, three program developers and a counselor were involved in the study. Choices made by each student for each instructional unit were recorded in files on the student's diskette. The program developers produced code written in BASIC for the TRS-80 Model IV, which would present the lessons in the format chosen for the particular developer. The Myers-Briggs Personality Type Indicator Survey self-scorable format was administered by the guidance counselor so that results could be entered on diskette by the student upon completion of the survey. Unit quizzes were generated randomly from a pool of questions supplied by the program developers. Unfortunately, there was no way to judge the equivalence of quiz questions, much less the equivalence of individual quizzes

The mean quiz score and percentage for each instructional unit follow (See Appendix K for data):

Input/Output Unit	9.26/20	46 3%
Arrays Unit	5.94/15	39 6%
String Functions	6.73/15	44.9%
Overall Quiz Average	21.94/50	43.9%

Note: Due to class period time constraints, the last two quizzes contained only 15 questions each.

Note: Many of the statistical tables that follow were generated to parallel Kathy's study for comparison purposes.

The following is the distribution of Myers-Briggs

Personality types for the individuals in the study (See Appendix I for complete data).

TYPE	COUNT
I - INTROVERT	21
E - EXTROVERT	13
N - INTUITIVE	20
S - SENSING	14
T - THINKING	15
F - FEELING	19
P - PERCEIVING	27
J - JUDGING	7

All 34 subjects were typed in all four dimensions through the use of the specified survey as listed below.

TYPE	COUNT	TYPE	COUNT
INFJ	2	ENFJ	2
INFP *	6	ENFP	6
INTJ *	1	ENTJ	1
INTP	1	ENTP	1
ISFJ	0	ESFJ	0
ISFP	2	ESFP	1
ISTJ *	1	ESTJ	0
ISTP	8	ESTP	2

* Indicates a developer type as well.

A distribution of temperament types is as follows:

TYPE	COUNT
NF *	16
NT *	4
SJ *	1
SP	13

* Indicates developer type also.

No comparative information was available on the distribution of personality or temperament types for the general school population, as the MBTI is not a standard evaluation tool used by the guidance department at McQuaid. However, a comparison to the pilot study for completely typed individuals showed the following distributions (See Appendix I for data).

	Kathy's	Study	Current	Study
NF	7	29%	16	47%
NT	4	17%	4	12%
SJ	13	54%	1	3%
SP	0	0%	13	38%

Only the NT temperament type indicates a similar distribution between the two studies The two sensing categories are so disparate in the percent of members to the total population, that one may come to believe that the kind of student who enrolls in these courses may have very different agendas. The course used for Kathy's study is geared toward non-technical majors The course at McQuaid is considered appropriate for college-bound students.

The frequency of viewing each of the four methods is divided into three groups. First, an overall view of the three topics of study showing the number of times each method was viewed, regardless of type, is presented (See Appendix L for data).

	TEXT	DEFINITIONS	GRAPHICS	EXAMPLES
TOTAL	217	214	244	202
MEAN	2.1274	2.0980	2.3922	1.9804
RANGE	8	10	7	7
S.D	1 8717	1.9429	1.5285	1.4839

VIEWING FREQUENCY -- ALL UNITS

Note: S.D. is standard deviation in all statistical tables.

A second breakdown looks at only the first topic of study in an attempt to disseminate the possiblity of curiosity affecting viewing, as opposed to the third breakdown, which looks at topics two and three in combination as possibly better predictors of choosing a methodology from previous experience with the format rather than for curiosity's sake.

	TEXT	DEFINITIONS	GRAPHICS	EXAMPLES
TOTAL	66	67	71	66
MEAN	1.9412	1.9706	2.0882	1.9412
RANGE	5	6	6	7
S.D.	1.2589	1.4448	1 1724	1.4540

VIEWING FREQUENCY -- UNIT 1

TOTAL	151	147	173	136
MEAN	2.2206	2 1618	2.5441	2.0
RANGE	8	10	7	7
S.D.	2.1063	2.1462	1.6577	1.5049

VIEWING FREQUENCY -- UNITS 2 and 3

The only global observations to be made concerning viewing frequency examine the graphics and code example methodologies The number of times the graphics format was viewed appeared to increase, while the example viewings decreased over the course of three units of instruction. The text and definition format viewing frequencies remained relatively constant. The distribution of frequencies is presented below.

	UNIT 1	UNITS 2 and 3	ALL UNITS
TEXT	24.5%	25%	25%
DEFN.	25%	24%	24%
GRAPH.	26%	29%	28%
EXAMPLE	24.5%	22%	23%

The changes were not significant but they were distinguishable. Like the pilot study, the graphics presentation was viewed most often, indicating at least a tendency, if not a numerically significant preference for the graphics mode.

The breakdown of User/Non-User, Game Player/Non-Player and Vocal/Non-Vocal student distributions, that were obtained from the use survey and subjective observations, is listed below for reference, both by personality dimension and temperament type. Note: Only the positive side of the characteristic is categorized in the tables. Appendix P contains the individualized data.

Dimension	Experienced User		Game Player		Vocal	
I	15	71%	11	52%	7	33%
E	7	54%	7	54%	8	62%
N	10	50%	11	55%	8	40%
S	12	86%	7	50%	7	50%
T	13	87%	8	53%	7	47%
F	9	47%	10	53%	8	42%
P	18	67%	14	52%	11	41%
J	4	57%	4	57%	4	57%
Total	22	65%	18	53%	15	44%

COUNT and PERCENT of DIMENSION

The profile of an experienced user, based on the higher percentage between dimension poles, appears to be ISTP. This seems slightly unusual at first glance. However, most computer applications tend to be step-wise, logical progressions, so STs should flourish. Introverts, by nature, keep to themselves. The computer will allow them to remain within their realm. Outside interaction is not necessarily required. The game-player facet appears to be evenly spread across all personality types. Vocal individuals present themselves as extroverts with judging tendencies. Vocal extroverts are the norm.

Type	Experienced User		Game Player		Vocal	
NF	7	44%	8	50%	7	44%
NT	4	100%	3	75%	1	25%
SJ	1	100%	1	100%	1	100%
SP	11	85%	6	46%	6	46%

COUNT and PERCENT of TYPE

A discussion of experienced, vocal, game players by temperament type is difficult because of the small number of subjects in the NT and SJ categories However, it is interesting to note that 85% of SPs are experienced users compared with 44% of the NF subjects. The learn-by-doing mode of operation of the SP type individual is well suited to many computer applications. Any further discussion of experience, however, must be tempered with restraint, since many students do not have control over most of the variables that were used to determine prior experience in the use survey (See Appendix J).

Data from the Post-Study Opinion Survey was analyzed in order to more easily quantify this data for supposed preferences. Each set of data was grouped by format. A median value was then calculated from the helpfulness range, 1-10 indicating least to most helpful Numbers above the median value indicated that the user found the presentation format useful Therefore, a preference for that format was recorded.

Statistical Analysis

Since the class was divided into two groups to accommodate the number of terminals for the duration of the study, simple analysis on the final average and quiz averages for the groups was performed. An analysis of variance (ANOVA) and T-tests for each of the quiz grades and the final average were performed, which indicated no significant difference between the two groups A table of means and medians for these elements follows.

Group	Quiz 1	Quiz 2	Quiz 3	Final Avg
A	8.18/8.0	5.35/5.0	6 00/6 0	83.35/81.0
B	10.35/9.0	6.53/7.0	7.47/8.0	85.41/86.0

MEAN/MEDIAN

A second analysis looked at the temperament types within each group and tried to assess the independence of the student's type from the group they were in. The group in which a student was placed should not have been affected by their personality type, as typing had not been completed at the time the groups were formed. However, certain biases may influence the proposed random grouping. A chi-square analysis of grouping by temperament type approached significance ($p < 0.25$). Even this "significance" is suspect, as the actual counts in half of the cells are less than 5 The low cell counts, alone, negate this result, indicating no discernible relationship between the group a student was in and his temperament type. The breakdown of group A/B by type follows.

GROUP	NF	SP	SJ	NT
A	9	8	0	0
B	7	5	1	4

TEMPERAMENT TYPE

Continuing the analysis using temperament type, indications of academic performance being related to type were investigated. An analysis of variance was calculated on final average and quiz average over the four types. Due to insufficient data for the SJs, inaccurate F distributions were generated. In an effort to overcome this difficulty, ANOVAs were run on the three most populated types and pairwise groupings of these three types. Each analysis indicated no significant difference within type. The following table represents accumulated statistics on academic performance by temperament type.

TYPE	QUIZ	SEMESTER 1	SEMESTER 2	FINAL
NF	43.1	83.9	82.6	83.6
SP	44.8	86.6	84.8	85.9
SJ	28.0	70.0	70.0	70.0
NT	46.5	86.5	85.8	83.5

AVERAGES

There was no one simple way to determine a user's preference for a method by looking strictly at frequency of viewing. The concept of using 3 as the cutoff viewing count, based on the idea that if a method was useful in one situation it would be used for the other lessons, is too limited. The presentations may have been too complex or just too long for one session at the terminal. The fact that a lesson was constrained by a timed class period indicates that a broader scope must be investigated. Because students rarely completed a lesson in one session (general observation), the cutoff frequency was set to 6, to allow the same idea of usefulness to apply, but adding the condition that this format would be chosen on two consecutive days for each lesson. The following table presents the counts and percentages by personality dimension for users indicating a preference through viewing frequencies greater than 6.

Count and Percent of Dimension

Dimension	Text		Definition		Graphics		Examples	
I	10	48%	11	52%	12	57%	9	43%
E	6	46%	8	62%	10	77%	7	54%
N	7	35%	9	45%	13	65%	10	50%
S	9	64%	12	86%	9	64%	6	43%
T	10	67%	10	67%	10	67%	7	47%
F	6	32%	9	47%	12	63%	9	47%
P	13	48%	17	63%	19	70%	13	48%
J	3	43%	2	29%	3	43%	3	43%

Preference by Viewing Frequency

Chi-square analyses were performed on each of the methods for preference by personality dimension. Only the N/S dimension for definition preference indicated a significance approaching ($p < 10$). As indicated earlier, the graphics format appeared to be the presentation of choice for all dimensions The code examples format appeared to have a consistent following near the half-way mark of each dimension, while the text and definition formats could vary as much as 40% within a dimension. It is interesting to note also, that more extroverts and perceiving types seemed to choose the graphics format in comparison to their counterpart types. Using the same target frequency number of 6, 24 viewings was calculated as a bounds for determining the user's need for a great deal of information for the four methodologies (6x4). The distribution of students who viewed more than 24 formats by dimension, along with the average quiz scores for all students in the dimension, is presented for comparison to Kathy's results. The counts and percentages recorded for each dimension indicate that each of the formats was at least somewhat useful to various students. This reinforces the hypothesis that different user types prefer different instructional formats.

Dimension	Count View > 24	% of Dimension	% Mean Quiz Score
I	7	33	50.2
E	8	62	33.0
N	8	40	43.7
S	7	50	43.5
T	7	47	42.7
F	8	42	44.3
P	12	44	45.6
J	3	43	36.1

Users Requiring Large Amounts of Data

It is interesting to note that the lowest percentage type, introverts (at 33%), performed the best on the quiz, while the type viewing large amounts of data the most, extroverts (62%), performed the worst on the quizzes. So quantity of instruction does not guarantee that more knowledge will necessarily be learned. In this case, it appears that less is better. Maybe the students overloaded their capacity for retaining information. The dimension, in which a difference would be expected, is the

N/S category. Sensing individuals are expected to use lots of data, while their intuitive counterparts tend to move quickly through information. There was some difference (10%) between the two poles but not a great deal. This small difference did not seem to affect the corresponding quiz scores, indicating that the sensing students were able to garner enough information from the lesser amount of data to perform equally well on the quiz No significance was found in any dimension for large amounts of data using chi-square analyses.

The preceding data on preferences is combined into temperament categories, strictly for general opinion and observations because of the small number of SJ and NT individuals in the study. Statistical analysis was performed using chi-square tests for preference of method by each temperament type and quantity of data required by type. No significance was reported in any test. However, a textbook type presentation was preferred by a majority of sensing/perceiving type individuals. The other formats and types had a wide range of cell counts and percentages indicating that one format would not be sufficient for all individuals.

Count and Percent of Type

Type	Text		Definition		Graphics		Examples	
NF	5	31%	7	44%	10	63%	8	50%
NT	2	50%	2	50%	3	75%	2	50%
SJ	1	100%	0	0%	0	0%	1	100%
SP	8	62%	10	77%	9	69%	5	38%

Viewing Frequency Preference

The formats chosen first and last by the student were also recorded in the study as a possible predictor of preference. Chi-square analyses were performed for the method chosen by temperament type in each unit and over all three units. Tables for this data follow the discussion. In examining first choices, only a very slight significance ($p < 0.25$) could be noted for the I/O and Arrays units. By simple inspection however, it can be noted, when looking at the totals, that more students appeared to choose the text format first (65% in I/O and strings, 41% in arrays). In reviewing last choices by lesson for all students, both definitions and examples each took a third of the class for the I/O unit. Thirty percent of the students chose examples last in the array lesson with the remaining 70% split almost evenly between the other 3 methods. In the final lesson on strings, 53% of the students chose to view the examples format last with almost 30% choosing the graphical presentation just prior to taking the quiz In general, examples did appear to be the method chosen last most often. However, when using the chi-square analysis mentioned earlier, no significance could truly be reported, as many of the cells of the first/last tables contain no elements. The raw data for these tables may be found in Appendices L and M.

	FIRST Choice by TYPE					LAST Choice by TYPE				
METHOD	NF	SP	SJ	NT	ALL	NF	SP	SJ	NT	ALL
TEXT	9	8	1	4	22	1	3	0	1	5
DEFN.	0	2	0	0	2	5	3	1	1	10
GRAPH.	7	1	0	0	8	3	4	0	1	8
EGS.	0	2	0	0	2	7	3	0	1	11

INPUT/OUTPUT LESSON

METHOD	FIRST Choice by TYPE NF	SP	SJ	NT	ALL	LAST Choice by TYPE NF	SP	SJ	NT	ALL
TEXT	4	6	1	3	14	5	2	0	1	8
DEFN.	5	3	0	0	8	2	4	0	1	7
GRAPH.	7	1	0	1	9	4	5	0	0	9
EGS.	0	3	0	0	3	5	2	1	2	10

ARRAYS LESSON

METHOD	FIRST Choice by TYPE NF	SP	SJ	NT	ALL	LAST Choice by TYPE NF	SP	SJ	NT	ALL
TEXT	8	10	1	3	22	2	0	0	0	2
DEFN.	1	2	0	0	3	2	2	1	1	4
GRAPH.	7	1	0	1	9	6	2	0	2	10
EGS.	0	0	0	0	0	6	9	1	2	18

STRINGS LESSON

METHOD	FIRST Choice by TYPE NF	SP	SJ	NT	ALL	LAST Choice by TYPE NF	SP	SJ	NT	ALL
TEXT	21	24	3	10	58	8	5	0	2	15
DEFN.	6	7	0	0	13	9	9	1	2	21
GRAPH.	21	3	0	2	26	13	11	0	3	27
EGS.	0	5	0	0	5	18	14	2	5	39

COMBINED LESSONS

Focussing the analysis on temperament type does not provide statistically significant results but does provide some interesting anecdotal results. For example, the one SJ student was very consistent in his choices. He tended to start with the text unit and finish with the examples unit when reviewing the lessons. Another interesting anomaly occurred in the strings lesson. No one chose examples first in any temperament type. As this occurred in the last unit of instruction, the realization that an explanatory introduction to the material may be a necessity prior to the hands-on approach of the examples method, is a very plausible explanation. By the end of the study, the students seemed to prefer reviewing a more practical approach just before taking the quiz possibly due to the nature of the questions. The habit of beginning a lesson at the top of the menu and proceeding to the last item on the menu may have slanted the results. Unfortunately, the order that the methodologies were presented on the menus did not vary, so the stated analysis is questionable. However, proceeding in order through a menu cannot explain the fact that approximately half of the NF students chose the graphical presentation first in each lesson. This variation seems to indicate that some other force is directing the choice.

The next set of statistics reports the results of the post-study opinion survey, which were quantified to indicate a format preference in terms of helpfulness to the user.

Count and Percent of Dimension

Dimension	Text		Definition		Graphics		Examples	
I	8	38%	10	48%	12	57%	13	62%
E	3	23%	3	23%	9	69%	6	46%
N	4	20%	5	25%	13	65%	12	60%
S	7	50%	8	57%	8	57%	7	50%
T	6	40%	6	40%	11	73%	6	40%
F	5	26%	7	37%	10	53%	13	68%
P	11	41%	12	44%	15	55%	14	52%
J	0	0%	1	14	6	86%	5	71%

Preference From Opinion Survey

As noted in previous discussions involving this set of temperament type individuals, care should be taken when reviewing these statistics because of the low cell counts for the SJ and NT subjects.

Count and Percent of Type

Type	Text		Definition		Graphics		Examples	
NF	3	19%	2	13%	9	56%	10	63%
NT	1	25%	2	50%	4	100%	2	50%
SJ	0	0%	0	0%	1	100%	0	0%
SP	7	54%	9	69%	7	54%	7	54%

Preference From Opinion Survey

Analyses were performed using chi-square distributions for helpfulness of a teaching method by each of the dimensions of the Myers-Briggs Personality Indicator. Opinion preference for the text format by the J/P personality dimension approached significance at ($p < .05$). However, this analysis did contain a table cell value of 0, which calls the analysis into question. A significance of ($p < .10$) was calculated for the relationship of definitions helpfulness to the intuitive/sensing trait and the relationship of code example formats to the T/F personality factor. No significance was realized in relating temperament type to any of the opinion survey preferences.

In the final sets of analyses, relationships are proposed for various combinations of experienced users, game players, and vocal subjects, related to each other and to the opinion survey. Prior to this however, analysis of variance statistics were generated for each of the academic criteria by user/non-user, game/non-game player and vocal/non-vocal subject T-tests were also run for each group on overall quiz average, semester averages, and the final average to maintain the independence of academic performance for these groups There was no significant difference of means in any group for each academic value. When the chi-square analyses were performed for the opinion survey format preferences to each group, three relationships developed. A significance of ($p < .05$) was observed in the graphics preference by user and similarly, by game player. Relating the text format preference to vocal/non-vocal student also approached significance at ($p < .05$).

Simple chi-square analyses were run between the different groupings and by temperament type. The following combinations were analyzed: (the positive poll of a category will be used for describing the analysis) user/game player, user/vocal, game player/vocal, user by type, game player by type, vocal by type and finally a series by A/B grouping to maintain the idea that the A/B grouping does not affect the independence of these other variables. No truly significant results were obtained. The relationship of user to game player did result in a significance level approaching ($p < .001$), as would be expected. One anomaly was noted in that all users are not necessarily game players, however, precluding the notion that being a game player must come before being a "true user".

<u>Human Analysis</u>

This commentary is based on reflections, concerns and impressions of the program developers. The study had some very discernible flaws. In an attempt to make the research broader, the difficulty level of the program may have been pushed to an unreachable plateau. What was considered a plus in research may ultimately be deemed a negative by almost all persons involved in this study. Certain uncontrollable factors may have placed an emphasis on issues which were originally intended to be considered independent variables in the study.

Expanding the base of learning material to three units of study may have been too much for the participants to grasp, without more preparation for the new environment. Going from a learning mode of textbook and lecture with notebook to almost entirely computer screen with notebook may be too drastic for many people. Although the students were familiar with the computer from small programming projects that were written out, typed in and executed, using the computer as the initial teaching mechanism may have been detrimental and overwhelming to some students. Using three distinct units of instruction was originally intended to force a definite preference of teaching methodology, as compared with learning the same basic concept, "loops", using three syntactically different forms. However, in trying to make that distinction, the program forced a do-or-die situation. The student had to find a way to learn the material in the I/O unit as it was used in the next two units, and similarly, the arrays material was used in the string functions unit. If the student needs a lecture atmosphere with questioning to excel, we have quite possibly buried him (not one level but three).

Although the same material would have been covered in approximately the same amount of time in the regular classroom, expecting every student to handle the same material, relatively independently, in the same amount of time, places an artificial time constraint on the student nullifying a portion of the original intent to allow the "type" to dictate how the student chooses to learn. The classroom environment and traditional class period requirements just don´t permit the time factor to be easily ignored. In Kathy's original study, time was less of a factor since the student could, within the bounds of the computer lab hours, work on the program for as long as needed. The student could control the time factor.

Other factors have affected the way the material was developed and, thereby, it´s effectiveness for the students. BASIC as a development language can be very restrictive. Though not a difficult language, it was foreign to one of the developers. Having never taught the language in a familiar environment made its use in a new arena even more challenging. Also each developer may have had an idea of the objective, but as individuals our interpretation of the ultimate goal for the class as a whole may not have matched that of the classroom teacher. For one developer, being isolated from the class made it difficult to judge the academic level of the students and incorporate that into the material. The only mode this developer could use as a base was college freshmen so there was a concern "I´m not sure I´m getting to them." However, the methodology developed was very familiar. Using examples is the preferred technique used by this developer in regular classroom instruction. "It´s fun making up examples."

As indicated earlier, time was a factor for the student in the typical class for a typical class period. Time also forced less than desirable circumstances for lesson development. Material for each lesson tended to be written too quickly There was no way to validate the equivalence of the three methods for any of the units. The presentations, in hindsight, may not have taught the same things with the same emphasis and thus penalized the students of one preference or another. The programs may not have been as "polished as we would have liked" and that in itself can cause a student to "turn off" his receptors. Another important factor to review is the imbalance in the difficulty level of the quiz questions. Since the questions were randomly chosen for a quiz, the equivalence of quizzes is not easily accepted. The idea of presenting the quiz online to prevent "sharing of information", may have made it difficult for those students who need to see it in black and white, not flashing green. Also the advantage of having access to the entire quiz at one time is apparent for those who use other information on a typical paper quiz to help discern the answer to the current question.

The ultimate dilemma for this researcher is the mixed emotions involved in this type of study There are two motivations. The primary goal of this study was NOT education. It was research/experimentation. The educator in me was often torn between staying detached and wanting so badly to help the student understand. Becoming emotional about the success and failure of the students has been my biggest handicap in presenting a non-biased research study As is discussed in the next section, the students have provided an interesting point of view for the use of such research.

<u>From the Students´ Eyes</u>

The students´ comments ran the gamut from "an extremely painful process" to "a very progressive idea." However, the comments were primarily personal in nature, and understandably so, rather than analytical with regards to the overall impact of the program.

A number of the participants were extremely concerned with the effect this "experiment" would have on their grades. They felt they were being punished for something they had no control over From an emotional viewpoint, they were angry that this "new learning experience" could destroy their GPAs (Grade Point Averages) and possibly affect their future academic career. Note: In terms of final grades, the study itself did not adversely affect any student's grade, as the instructor has final say in all grading procedures. However, this anxiety over grades may have influenced the student's performance not only on the quizzes but also in the way a student approached and proceeded through a lesson. For some participants, the study started out as a game or even worse a non-entity; something they could ignore. They saw the CAI class as an opportunity for an extra study hall until the first quiz was completed and the results were made known .. then came the anger and frustration. Many students felt the quiz questions did not properly reflect what had been presented in the lesson. So the comment "the quizzes were too hard" was repeated several times. Certain students said the material was "deceptively easy." Reviewing a lesson until they believed they understood it only to take the quiz and perform poorly, left some students feeling disgruntled and discouraged. Curiously, one young man's comment may shed some light on this point. "I was too tempted to just click through the screens and too lazy to go back and review." This comment reflects not only on the limitations of the machinery but also on the motivations of the student.

Often students commented on the mechanics of the presentation. As noted earlier, the hardware and software constraints left us with less than desirable circumstances. The most vocal comment in this arena referred to the inability to "flip back" a screen as you would a page in a textbook. For those students who are notetakers, flipping back and forth to reread sections or review examples is critical Since the lessons were designed as "run throughs", starting in the middle of a lesson was not possible, so a student would find himself back at the beginning of a lesson when he only needed to review the last section. This frustration was mentioned from different points of view. Some commented on their own short attention spans, while others noted the problems they have with CRTs and their difficulty viewing material displayed on the screen because of headaches, poor eyesight or a need for audio rather than visual stimuli. One student tape records and repeatedly plays back lessons to facilitate learning. His recognized disability put him at a great disadvantage in this environment.

One very disturbing comment heard more than once involved students discouraged by the first quiz. "I give up." This, along with comments about the difficulty of the quiz questions before everyone had taken the quiz, placed a few students in the mindset of 'why should I try' Comments from other students regarding their unpreparedness for a quiz, because they are not notetakers or they don't know what's important enough to take notes on, forced a compromise. Hardcopies of the screen displays were provided where appropriate after the quiz was completed for a unit. With hardcopy in hand and an opportunity to make use of the lesson in a programming project, most students were back on track. But the influences of others still pervaded the study. Comments between classmates during the run throughs regarding the ease of a format, how "neat" a graphics display looks or how "boring" reading this text is, may have prompted another student to choose a format he might not have looked at otherwise.

One final point of contention for the students involved the scheduling of the lessons, since the class had to be divided into two groups. Some would have preferred continuing with lab classes until the entire lesson was complete rather than alternating, two days lab/two days lecture Others welcomed the respite they found in getting away from the lab after two days of "just the PC".

After the study was completed and the students had somewhat "recovered" from their experience with CAI, they were given the opportunity to express their opinions (good, bad and indifferent) about the project, both in an open discussion forum and by "pseudo" anonymous essay (The students were not required to sign the essay but an overwhelming majority chose to do so) It is from these two pools of information that the following comments are drawn rather than a statistical analysis of the formalized Opinion Survey (Appendix O).

Unfortunately, the majority of the comments were negative by a larger number of participants, unfortunate for two reasons. First, the negativism indicates that the lessons failed to meet the classroom goal of teaching computer science. Secondly, the not so pleasant experience will tend to discourage the student from seeking further opportunities and situations involving computers.

When reviewing the types of comments made with respect to the temperament type of the person making the comments, it was interesting to note that intuitive feelers (NFs) tended to make general comments about the program, good and bad; while sensing perceivers (SPs) commented on the specific methodologies. The four intuitive thinkers (NTs) concentrated on personal comments. The four types of student also seemed to categorize the methodologies they preferred, as was expected in this study.

One student commented that the graphical presentation was "much more beneficial" than the others. He felt the other methods were more difficult. Another student "found the code examples to have the most value. .you could actually participate and not just stare into a screen." A third student "liked the code examples the best. This made it seem like the computer was teaching...Learning from experience." They each showed a need for an interactive environment. These three students had temperament type NF. On the other hand, one SP student thought that "the text style was neat." But "it would have been easier to have a hardcopy Likewise I would have found it easier if I had the definition portion written or printed out as well." A second student with temperament type SP commented "the text part explained a lot to me the definitions were also good. The graphics served no purpose for me. The code examples were helpful because they quizzed me...I found the text most helpful though." However comments from a different student showed the frustration he felt. "My attention span grew very short while trying on-screen learning. Not being able to ask a computer questions is also a problem." Another student "had a hard time focussing due to the lack of a human touch. I prefer to listen to a teacher than to read a screen."

Each of these students along with their comrades had opinions, suggestions, problems and frustrations. Each student had a definite personality somehow reflected in his different point of view. These differences, varied though they are, have a pattern which we have tried to investigate, quantify and interpret to better facilitate the learning processes of the future.

Two Studies in Contrast

When analyzing the success or failure of this study, providing a comparison to the pilot study has been most illuminating for this researcher Several differences which were hoped to be significant research factors tended to fade while other seemingly benign differences may have influenced the study beyond expectation or want.

The two groups, while both student populations and most likely similar in age, may have differed in a critical point of maturity. The high school students may not all be able to adapt to the self-motivating environment required for ITS However, the environment itself may be to blame. A classroom filled with your friends and comrades may be more distracting than a computer lab which may or may not present you with friends or even acquaintances to interrupt or influence your behavior. As discussed earlier, the lab itself provides a place where time can be factored out of the equation for learning a lesson which tends to be critical for certain temperament types. The classroom and class period are not so flexible and the artificial time constraint is evident. Out of necessity, the classroom is more structured. Students must finish the assignment followed up by a programming project. Those in the computer lab have only this one assignment to complete in order to be considered finished.

The students in the second study were not given a choice as to being involved in the research. It was part of the curriculum for those three units of instruction. Those in the first study were presented with this process as a means to receive extra credit. Their motivations for completing the study would tend to be less compelling, but their anxiety over the results would also be greatly reduced. As indicated by many of the high school students, their grades were affected positively and negatively by something they all considered totally experimental; whereas the college students could only be rewarded for their participation, not punished.

Both courses were Beginning Computer Classes. One using what would be considered almost obsolete equipment and a limited programming language in comparison to its counterpart which was not trying to teach a language so much as programming concepts.

One group was all males who interacted as they proceeded through the lessons. The other group was a combination of males and females who probably did not have much contact during the course of the research study, unless meetings were planned in the lab.

Finally, in one situation the researcher was able to maintain objectivity since only the lab proctor had contact with the students. The other situation allowed the observer to create attachments to the subjects, which may have influenced future lesson and quiz development. In the case of three distinct units this is a plus for purposes of teaching the student what is required. For purposes of a strict research study, this will bias the design of the next unit and conform to student expectations rather than designer preferences (by type). However in any research involving human beings, we cannot eliminate the human equation completely without becoming robots ourselves

CHAPTER 7. CONCLUSION

Expectations

In pursuing this study, I have tried to eliminate or at least reduce some of the limitations and biases found in the previous study.

One limitation of Kathy's study was the relatively small population. With only 24 completely typed individuals, results could be suspect. Also, the fact that computer majors are steered away from the Survey course will tend to bias the group toward more non-technical students. Finally, the voluntary nature of the lab work used as the basis for the study will not necessarily give a representative subset of the user population. Those involved in the study have already shown a separate motivation by participating. The study conducted at McQuaid involves a slightly greater number of completely typed students from various backgrounds and with differing levels of skill. A "good" mix of students was found at the Senior High level of instruction with a variety of interests, abilities and experiences.

A second bias which I have tried to remove is the use of a single designer for the instructional material. Providing material developed by multiple individuals with different personality types gives the student the opportunity to choose a method, hopefully more suited to his/her own personality as related to the personality type of the designer of the particular method.

In Kathy's study only one basic unit of instruction was provided, loops. Even though three constructs were taught using the different methods, the short time span and limited material may have been insufficient to allow the student to really determine an instructional preference. Choosing multiple methods may have been more a question of curiosity than a true choice of preferential method. In the course of three distinct units of material, a pattern in type of instruction should emerge. With multiple units, the problem of a student "just not understanding" a particular concept regardless of method should be lessened.

As part of my study, I have attempted to evaluate the impact of prior knowledge of and experience with computers on an individual's approach to working with a computer as it relates to the student's personality. This information was made available through a survey concerning prior use presented to each student at the beginning of the study. Personal observations are also incorporated into this evaluation My ability to observe first-hand the difficulties and approaches of various students has provided another viewpoint for interpreting the collected data.

Finally, I hope I have been able to develop computer based instructional material which can be used by future classes at the school, regardless of the results of the research study. This material is a building block for future computer instruction and generates a springboard for a possible intelligent tutoring system on-site.

Limitations

While many of the limitations of this study have already been discussed in the 'Studies in Contrast' section of Chapter 6, a review of these drawbacks will propel us into a better future. Without a proper research base, any study is doomed to, if not failure, at the least, mediocrity. The pool of subjects for this study, although restricted in gender, was also restricted in number and therefore, spread across personality dimensions and temperament types. Most of the analysis, that was attempted by type, was statistically flawed. The preliminary study that was originally proposed would have contained the input from approximately 400 students using LOGO with turtlegraphics on APPLEs The limited hardware and software resources forced the development of learning materials that were far from "state of the art". The relatively simplistic user interface that was coerced by the available materials, greatly affected the usefulness of the system, and as noted in the 'Human Analysis' section, negatively influenced the effectiveness of the program from the students', as well as the developers' perspectives.

The system placed the students in a learning forum that was foreign to them, in the middle of a school year, with a class structure not suited to independent, self-directed learning. The short-term nature of the study, the grouping forced by class size and the class period format of the learning environment, each contributed to a disruptive and disrupted educational setting.

The evaluation of learning should not reside only with the traditional test format, since this will prejudice the indicators of achievement against those students who do not test well. Another evaluation tool, such as a programming project should be required to provide the non-test taker with an opportunity to succeed.

External influences from fellow students, textbooks, and learning aids were uncontrolled variables in this study. The classroom setting does not allow for effective monitoring of these inputs.

The limitations may seem overwhelming but the concept is sound and the proposition for future work is promising. As Bork reiterates, "We are only beginning the task of learning how to use computers in education." (BORK81)

In The Future

Although the results of this study were not overwhelmingly supportive of the original theory relating personality and learning preference, there is no indication that this is not a viable direction for future investigations. Improvements to this study, based on the observations, concerns and conclusions of the varied persons involved, should provide the basis for a more precise and less "hazard" laden study.

The proposed study would continue the task of trying to relate learning preferences to personality type. As the Myers-Briggs Type Indicator provides a simple way to produce complete typing in all categories, its use is still recommended for the study. To provide a comparable base of students, the research should again be conducted in an introductory level course, but with a much larger student population (as was hoped for in the initial stages of the current study). Also, a comparison of the class population to the entire student body with regards to the Myers-Briggs scores is desirable. If the number of students who take the course compared to the entire student population is skewed with respect to personality type, a different venue for the experimental study may be necessary. Therefore, for the grade level being considered, using a required course in this research would be ideal. The goal of increasing the student base does not preclude the use of temperament types as indicators of personality and user characteristics. Keirsey's temperament types still provide a concise delineation of attitudes, learning habits and tendencies. The Myers-Briggs Personality Types would still produce too wide a range of categories, both for analysis and for methodology preparation.

Even though the study presented here expanded the scope of the material to three units of instruction, the proposed study should still attempt to broaden the platform for obtaining preference data. A long-term study, spanning the entire course, is desirable for two major reasons First, the amount of data that can be gleaned from the expanded study would be more likely to show more readily definable patterns of choice. Second, the "shock" of changing from a teacher-directed to a self-directed learning environment will be lessened. The student will eventually develop a "formula" for reviewing the material that is most helpful to him/her Along with the traditional methods of evaluation (quizzes), a more application oriented assignment should be provided to encourage the student who needs to see a practical use for learning something (SPs).

The hardware and software limitations, discussed earlier, were primary impediments to the development of a powerful learning tool and experimental resource. A new study should attempt to incorporate more advanced software development tools and strategies, especially in terms of graphics, windowing and interactive processors. This would naturally requre more advanced hardware than the TRS-80 Model IV machine using BASIC.

The actual design of the lessons by different developer types should produce different styles of presentation. Each one of the four temperament types should be represented in the pool of developers. As in the current study, each developer should present entire lessons based on course descriptions for each unit of instruction. However, the matching of style to developer is not an appropriate distinction for presenting the choices to the user. (ie. the text version should not be "assigned" to the SJ developer, etc.). A different description of the lesson style options will be required. Its exact format is not yet known. The overwhelming support accorded the belief that "designers design for themselves" (VAND85) makes the multiple designer format paramount.

The first/last choice data collected in the current study produced anecdotal results, at best, because of the menu interface provided. With more careful use of the strategy, more relevant data may emerge, which could engender more statistically significant results.

Although the opinion survey is far from scientific in the current study, a future study could use the same type of information as a counterbalance to the preferences indicated strictly by method choices. How a student perceives a situation can be just as telling as how the student reacts in the situation. However, both opinion and choice variables can be affected by outside influences, including classmates, textbooks and teachers, as was seen in the current study. At this stage of the research process, isolating the students to control these factors is neither practical nor prudent.

Considering outside influences and trying to judge user experience, in order to analyze the differences in the study population, is a difficult task. Trying to quantify prior user experience, in an attempt to remove it as a variable from the relationship equation, is almost impossible. The only way to equalize this variable for all participants is to guarantee that no one has ever used or seen a computer before. This is unrealistic. A survey of software and hardware used and for what time period may be helpful, in addition to determining computer use in other academic arenas and entertainment forums.

Epilogue

With all of its faults and failings, this research study has presented a new generation of students and a not so new generation of educators with some important concepts and questions about Intelligent Tutoring Systems, and their place in the classrooms of today and tomorrow

The development of ITS is a slow and evolutionary process but the directions to a complete solution are becoming clearer with each step. The idea of marrying user characteristics to learning preferences in order to provide a more responsive tutoring environment is exciting. The process of mapping those characteristics to learning paradigms is difficult and far from straight foward, as indicated by current research efforts. However, the process is still developing and the concepts are still valid, at least from this researcher's point of view.

The future of ITS for the traditional classroom may still be at a distance, but the need for the development of Intelligent Tutoring Systems in a viable environment is paramount. The research must continue to explore the realm of the computer from the user's vantage point.

SAMPLE ITEMS FOR THE

MYERS-BRIGGS TYPE INDICATOR ®

FORM G

by Katharine C. Briggs and Isabel Briggs Myers

There are no "right" and "wrong" answers to these questions. Your answers will help show how you like to look at things and how you like to go about deciding things. Knowing your own preferences and learning about other people's can help you understand where your special strengths are, what kinds of work you might enjoy, and how people with different preferences can relate to each other and be valuable to society.

Part I: Which Answer Comes Closer to Telling How You Usually Feel or Act?

4. Do you prefer to
   (A) arrange dates, parties, etc., well in advance, or
   (B) be free to do whatever looks like fun when the time comes?

21. Do you usually
    (A) value sentiment more than logic, or
    (B) value logic more than sentiment?

Part II: Which Word in Each Pair Appeals to You More?
Think about what the words mean, not how they look or sound.

39. (A) systematic
    (B) casual

64. (A) quick
    (B) careful

Appendix B

COMPUTER USE SURVEY

The following is an experience survey in which you will be asked several questions about your prior experience with computers. Please answer all questions to the best of your knowledge. There are no right or wrong answers in this section.

1. Please enter your age:

2. Do you own or have access to a computer outside of school? (Y/N)

   [If yes, the computer prompted questions 2A and 2B otherwise question 3 was presented.]

   2A. How many hours per week do you use this outside computer?

   2B. What do you use it for? (Enter all that apply.)

      1. GAMES
      2. SCHOOL WORK FOR THIS CLASS
      3. SCHOOL WORK OTHER THAN THIS CLASS
      4. WORD PROCESSING
      5. OTHER

      [If option 5 was chosen, the student was prompted to specify in sentence form with items separated by commas.]

3 Do you use the classroom computer outside of class time? (Y/N)

   [If yes, the computer prompted questions 3A and 3B otherwise question 4 was presented.]

   3A. How many hours per week?

   3B. What do you use these computers for outside of class time? Please enter all that apply

      1. GAMES
      2. COMPUTER CLASSWORK
      3 OTHER CLASSWORK
      4. WORD PROCESSING
      5 OTHER

      [If option 5 was chosen, the student was prompted to specify in sentence form with items separated by commas.]

4. Do you know any computer languages other than BASIC? (Y/N)

5 Have you ever taken a computer class other than this one? (Y/N)

Appendix C

INTRODUCTION

THE FOLLOWING IS A RESEARCH STUDY INVESTIGATING THE RELATIONSHIP BETWEEN COMPUTER AIDED INSTRUCTION AND THE USER'S CHARACTERISTICS. THE SYSTEM IS DESIGNED TO PRESENT THREE DIFFERENT TOPICS IN THE BASIC LANGUAGE USING A VARIETY OF METHODS. EACH TOPIC IS CONCLUDED WITH A MANDATORY QUIZ. UPON ENTERING THE PROGRAM FOR THE FIRST TIME THE USER WILL BE PRESENTED WITH A BRIEF QUESTIONNAIRE. FOLLOWING THIS THE NORMAL STARTUP PROCEDURE WILL PROMPT FOR THE STUDENT'S MYERS-BRIGGS TYPE INDICATOR. THIS PROMPT WILL BE ASKED AT THE START OF EACH SESSION UNTIL THE PERSONALITY SURVEY HAS BEEN TAKEN AND THE PROMPT IS ANSWERED. THE USER WILL ALSO BE ASSIGNED A NUMERICAL CODE WHICH HE WILL HAVE TO ENTER AT THE START OF EACH SESSION.

Press <RETURN> to continue.

Appendix D

Topic HELP Instructions

This program will present material on the topic of ...

The material will be presented four different ways:

The Text Presentation is a narrative explanation of how ... and the corresponding BASIC representations are used.

The second presentation is in terms of a series of definitions.

The Graphic Presentation explains the same material by portraying the way the computer processes each statement.

The final presentation is done in terms of several examples of computer routines using these statements.

Each presentation is complete in itself. You should choose first the one that you think best fits with your own way of studying.

After studying that presentation you may look at the others if you want to or you may go directly to the quiz after one presentation.

You may review each presentation as many times as you wish.

You may take notes on the presentation as you read through it.

After you feel you have learned the material, you must take a quiz on the material on the computer

You will only be allowed to take the quiz once.

If you have any questions, ask your instructor before proceeding

Appendix E

QUIZ INSTRUCTIONS

The following quiz should be taken upon completion of the Topic ... Section. The quiz consists of 15 multiple choice questions which will be displayed on the screen one at a time. You are not allowed to use your notes. The quiz will be graded and you will be given a hardcopy of the questions when the entire class has completed this section.

You will be prompted for the correct answer after each question is displayed. If you are not sure of an answer, you may skip it the first time through by typing a P for PASS at the Answer prompt. You may only Pass a question once. Any questions that you pass over will be displayed again after the initial run through of all 15 questions. You MUST answer it the 2nd time around. If you have any other questions, please ask the instructor. NOTE: This quiz is to be treated like other quizzes in that it is closed notes, closed mouths and OPEN MINDS. GOOD LUCK!

Appendix F

Post-instruction Helpfulness Survey

COMPUTER SCIENCE
Fr. Stump. S.J.

Name . . . . #....
04/25/90

1) Our Computer Assisted Instruction Project presented each chapter in four ways. Please rate each from 10 (very helpful to me) to 1 (useless to me.)

..... Textual presentation

..... Definitions

..... Graphical presentation

.... Code examples

2) Future lessons could be planned using text, machine or both. Please rate each of the following from 10 (would be very helpful to me) to 1 (would be very hard for me.)

Text alone

Machine presentation alone

. . Text and machine presentation

PROGRAM SCREEN DISPLAYS

NOTE: Blank lines have been inserted/deleted for readability
Lines enclosed by [ ] are explanatory in nature.

TEXTUAL EXPLANATION OF SPECIAL I/O COMMANDS
-- READ DATA RESTORE PRINT USING --

Up to this point, if we wanted to get data into a program we used an INPUT statement and entered the data one value at a time during program execution. READ, DATA and RESTORE are used together to process long lists of data values without having to type in the information at program runtime. These statements work best for data that changes infrequently, such as Employee Payroll Data where the name and hourly rate don't change every week just the hours do. Also, data to be used for various functions or in different parts of the same program is a good place for these statements. Data values for which multiple arithmetic operations need to be performed, like finding the average, median and mode of a group of numbers, fit READ/DATA/RESTORE commands

The DATA statement stores the data values as part of the actual program. The READ statement accesses the values specified after the DATA statement(s) and places those values in the variables listed after the READ. A data pointer keeps track of the last value read from a DATA statement. NOTE: If you try to READ a string value into a numeric variable, a ?SN Error (SYNTAX) will occur.

```
100  READ V1, V2, V$
200  DATA 10, 20
210  DATA MCQUAID
```

V1 now contains 10, V2 contains 20 and V$ contains MCQUAID.

The RESTORE statement sets the data pointer back to the first data value in the first DATA statement. This allows the program to READ the same data values into other variables reusing the data for another purpose. If the data pointer is not reset and more READ variables are specified than data values. an ?OD Error (OUT OF DATA) occurs.

```
100  READ V1, V2, V$
150  RESTORE
200  READ V3, V4
800  DATA 10, 20
810  DATA MCQUAID
```

V1 and V3 contain 10 ; V2 and V4 contain 20 and V$ contains MCQUAID and the data pointer is set to MCQUAID.

In general, we try to group the DATA statements together near the end of the program to make updates easier and program flow easier to follow since a READ statement anywhere in the program will access the next available data value pointed to by the data pointer.

The PRINT USING command is used to format displayed output in a more readable fashion. Data can be formatted into columns, rounded uniformly, and sized equally along with enhancing the display PRINT USING provides these special display features for numbers and strings with field specifiers or formatters. A field specifier is made up of special format characters enclosed in quotes Any character in a field specifier which is not a special format character will be displayed as is.

```
PRINT USING "field specifier"; variable list
```

Field specifiers for numeric output include # - + $ $$ ** **$, . The # is the place holder. Numbers are aligned with the specified decimal point with the series of ## indicating the number of digits to be displayed.

```
PRINT USING "##.##"; N    (Leading -)
PRINT USING "## ##-";N    (Trailing -)
PRINT USING "##.##+";N    (Trailing + or -)
PRINT USING "+## ##";N    (Leading + or -)
```

Whole numbers smaller than the specifier cause leading spaces to be inserted. Whole numbers which overflow on the left cause a % to appear in the output indicating the number was too big for the field specifier Decimal portions too large are rounded. Decimal portions too small are zero-filled on the right

```
PRINT USING "$####.##";N  ($ in position specified followed
                           by leading blanks and the number)
PRINT USING "$$##.##";N   (No spaces between $ and 1st digit)
PRINT USING "**##.##";N   (* fill all leading blanks)
PRINT USING "**$##.##";N  ($ just ahead of 1st digit,
                           * fill any leading blanks)
PRINT USING "####,###.## DOLLARS";N
```

The floating comma specifier only needs to be entered once and it will appear as many times as required for thousands, millions, etc. The DOLLARS string is a literal which will follow the formatted number as is.

Field specifiers for strings include ! \\ and literal strings as described below.

```
PRINT USING "!"; N$,M$  (Get the 1st character in string)
```

The ´!´ is re-used for each string so the 1st character of N$ and the 1st character of M$ are displayed next to each other

PRINT USING "! "; N$,M$ inserts a blank between the two characters.

```
PRINT USING "\\"; N$  (Gets 1st 2 characters of N$)
PRINT USING "\ \";N$"  (Gets 3 characters, each imbedded
                        space gets another character.)
```

If the string is shorter than the field specifier, trailing blanks are added to fill the length of the specifier. If the string is longer, the display is truncated.

DEFINITIONS

READ -- BASIC statement which performs I/O by accessing data stored within the program code rather than getting it during program execution (like INPUT). Useful for large quantities of data or data that doesn´t change very often. Used with one or more DATA statements.

SYNTAX: READ variable list
Example: READ V1, V2, N$

DATA -- BASIC statement which ´stores´ data values as part of the actual program rather than inputting data at runtime. Accessed by one or more READ statements, DATA statements must come somewhere after the READ; often grouped together at the bottom of the program.

SYNTAX: DATA data values
Example: DATA 20,30,GILLIGAN

Data pointer -- internal indicator that keeps track of the last data value read from a DATA statement. If there are no more values for the DATA statement, the pointer moves to the next DATA statement. If there are no more DATA statements, an ?OD Error (Out of Data) Message is generated.

RESTORE -- BASIC statement which resets the data pointer to the first value in the first DATA statement. Allows data to be read again by another READ statement.

SYNTAX: RESTORE

?OD Error -- Out of Data Error message displayed when a READ statement is executed after the last data value of the last DATA statement has been read. The data pointer is positioned at the last available data value. A RESTORE statement or more DATA statements are required for successful execution.

?SN Error -- Syntax error message displayed if you try to READ a string data value into a numeric variable. The message indicates the error at the DATA statement line number instead of at the READ

```
PRINT USING -- BASIC statement used to format displayed output
               for better readability and uniformity.  The format
               is determined by numeric and string field specifiers.

                  SYNTAX: PRINT USING "field specifer";data list
                  Example: PRINT USING "**$### ##";25.657
                  Output: ***$25.66


Field specifier -- format specification for PRINT USING made
                   up of special format characters enclosed in
                   quotes and separated from the data list by a
                   semicolon.  If there is more than one item
                   in the data list, the specifier is re-used.
                   Any character in the specifier that is not
                   a special format character is displayed as is.

Special numeric format characters -- ##   - + , $ $$ ** ***

If the data item is larger than the format specifier, the
number is displayed preceded by a %

Test Data: T1 = 11345.3   ,   T2 = -342.458

Example:   PRINT USING "##.##+"; 78,3.466,-11.2,673.5
Output : 0.78+ 3.47+11.20-%673.50

Example: PRINT USING "-##.##  "; 78,3 466,-11.2
       : 0 78   3.47  -11.20

Example: PRINT USING "$####.##   ";35.268,177 3
       :$  35.27  $ 177.30

Example: PRINT USING "**###,###.## DOLLARS ";1400346 357,T1
       :*1,400,346.36 DOLLARS ***11,345 30 DOLLARS

Example: PRINT USING "$$###.## ";456 78,12.2
       : $456.78   $12.20

Example: PRINT USING "**$##.##-  ";T2,12.1
       :*$342.46-  **$12.10

String format specifiers -- ! \

Test Data: N$="MARIO" , L$="BROTHERS"

Example: PRINT USING "!";N$,L$
Output :MB

Example: PRINT USING "! ";N$,L$
       :M B
```

```
Example: PRINT USING "\\ KNOWS BEST";N$
       :MA KNOWS BEST

Example: PRINT USING "\ \";N$,L$
       :MARBRO

Example: PRINT USING "  \       \";N$,L$
       :  MARIO    BROTHER
```

BASIC CODE EXAMPLES OF ARRAYS

In the code section on special I/O, we developed a program to process student test scores The program contained a group of DATA statements at the end of the program file with the number of students followed by a name and 3 test scores for each student. The final output was two tables of information the first a table of test scores, the second the average test score for each student. In order to create the two tables, one after the other, from only one set of data, we used the RESTORE statement to process the same DATA twice The program and corresponding output is listed on the next page.

```
100 PRINT "STUDENT    TEST 1   TEST 2   TEST 3"
110 READ NSTUDS
120 FOR I = 1 TO NSTUDS
130    READ N$,T1,T2,T3
140    PRINT USING "\          \";N$;
150    PRINT USING " ####       ";T1,T2,T3
160    NEXT I
170 PRINT : PRINT "STUDENT   TEST AVG"
180 RESTORE
200 READ NSTUDS
210 FOR I = 1 TO NSTUDS
220    READ N$,T1,T2,T3
230    LET TAVG = (T1 + T2 + T3)/3.0
240    PRINT USING "\           \ #### #";N$,TAVG
250    NEXT I
800 REM DATA SECTION
810 DATA 3
820 DATA HULK,75,90,85
830 DATA GILLIGAN,35,33,54
840 DATA DOOGIE,100,100,103
900 END
```

With the following output:

```
STUDENT     TEST 1   TEST 2   TEST 3
HULK          75       90       85
GILLIGAN      35       33       54
DOOGIE       100      100      103

STUDENT    TEST AVG
HULK          83.3
GILLIGAN      40.7
DOOGIE       101.0
```

The RESTORE statement allowed us to produce the two tables by processing the same block of DATA statements twice. This works, but it is not very efficient. What we would like to do is read the data one time into variables and produce the two tables by processing the data stored in the variables. The problem is we would need a lot of variables to hold all of the data.

Fortunately, BASIC gives us the ability to create a variable that holds more than one piece of data. This type of variable is called an array and they are created with the DIM statement (short for DIMension). How many pieces of data would you guess X could hold if it is created as follows:

```
DIM X(15)
```

[Pause for response. Correct answers generate complimentary message]

The answer is 16.

This may seem strange but the way TRS80 BASIC handles arrays there is room for 16 values, positions 0 to 15 in the array So X(0), X(1), X(2) ... X(14), X(15) are all memory locations in the array X which can hold data values

We can think of X as a row of 16 different variables, each of which can hold a different piece of data. The number in parentheses in the DIM statement indicates how big the array is The number in parentheses for each memory location X(0), X(1), etc. indicates its position in the array.

How would we put 77 into the first of the 16 X variables?
A) LET X(0) = 77 B) DIM X(77) C) LET X(77)

[Pause for response (see above)]

The answer is A.

The 0 in the parentheses in this LET statement is called an Array SUBSCRIPT. It points to the first of the 16 'elements' of the array X. Which of the following would NOT work, assuming X is defined as above with DIM X(15)?

A) LET X(1) = 55 B) LET X(15) = 55
C) LET X(16) = 55 D) LET X(9) = 55

[Pause for response (see above)]

The answer is C.

If we tried accessing X(16), the system would respond with a ?BS Bad Subscript error message and stop processing, because that position in the array X was never defined by DIM Similarly, if a NEGATIVE subscript is used, a ?FC Function Call Error message is generated. If an array is used without first providing a DIMension statement, the default value of 10 is used for the array.

We can use a variable for the subscript instead of a constant, like the counter in the FOR loop shown below.

```
10  DIM X(15)
20  FOR I = 0 TO 15
30    LET X(I) = 44
40    NEXT I
```

What do you think would happen?
A) The first and last elements of X will contain 44.
B) All 16 elements of X will contain 44.

[Pause for response. (see above)]

The answer is B.

Without using the FOR loop index I as the subscript you would need to write 16 separate assignment statements (LET) :

```
10 LET X(0) = 44
20 LET X(1) = 44
30 LET X(2) = 44
40 LET X(3) = 44
50 LET X(4) = 44
60 LET X(5) = 44
70 LET X(6) = 44
80 LET X(7) = 44
90 LET X(8) = 44
100 LET X(9) = 44
110 LET X(10) = 44
120 LET X(11) = 44
130 LET X(12) = 44
140 LET X(13) = 44
150 LET X(14) = 44
160 LET X(15) = 44
```

It is not necessary to start with subscript 0 when processing an array. Any valid element of the array can be accessed by providing the appropriate subscript. Often for readability, array access starts at position 1. Any array position not given an explicit value, defaults to 0 if it is a numeric array variable and blanks if it is a string array.

One major use of arrays is in accumulator type applications where we count the number of items classified a certain way. For example, if we wanted to count the number of videotapes sold in a store by type; such as 1. Western, 2. SCI-FI, 3. Horror, 4. Romance, 5. Comedy, 6. Action, 7. Cartoon, etc.; we could create an array called TAPE. Each subscript would represent a type of tape. DIM TAPE(7). If we need more types, we can increase the size of TAPE.

```
10   DIM TAPE(7)
20   PRINT "Enter -1 to quit!"
30   REM LOOP
40   INPUT "Enter tape type number",N
50   IF N < 0 THEN GOTO 90
60   IF N < 1 OR N > 7 THEN ? "RE-ENTER" : GOTO 30
70   TAPE(N) = TAPE(N) + 1
80   GOTO 30
90   :
```

The program ups the count by 1 for a specified type of tape each time the tape type # is entered.

We could set up a second array which contained the names of the tape classification types.

```
100  DIM TYPE$(7)
110  FOR I = 1 TO 7
120     READ TYPE$(I)
130     NEXT I
140  DATA WESTERN,SCI-FI,HORROR,ROMANCE
150  DATA COMEDY,ACTION,CARTOON
160  :
```

Finally if we add a PRINT LOOP, we can produce a report of our sales.

```
170  PRINT "TAPE TYPE    SALES"
180  FOR I = 1 TO 7
190     PRINT USING "\       \     ####";TYPE$(I),TAPE(I)
200     NEXT I
210  END
```

In general, we can give a dimension statement anywhere in the program before using the array variable or if we don't specify DIM, the default of 10 is used. However once we have given a DIM statement for an array or used the array, giving a second DIM statement for that SAME array will cause a Double Dimension (?DD) error. We must also be prudent in the size of arrays. If we make a DIMension too large, we will get an ?OV OVERFLOW Error message.

Now let's return to the student grades program. How can we use arrays to keep from processing the same block of DATA statements twice (we don't want to use the RESTORE command)?

A) Create an array for the name and arrays for each test score.
B) Create an array for a single student's information.
C) Create arrays for the name, each test score and the average.

[Pause for response (see above)]

Either A or C would work.

Creating a single array for all of a student's data will not work because the name must be stored in a string variable and we want to store the test scores as numbers When you create an array, all of the elements must hold the same kind of information.

For the following version of the grades program, we will use 5 arrays; one for the names, one for each of the 3 tests and one for the average. As you look at the program, take note of lines 100 through 220. This section of the code reads and processes the data for both tables without having to RESTORE the data to calculate the average. Also note that we have defined the maximum number of students we can handle to be 40 (the dimension of each array.) Line 30 of the program makes sure we don't exceed the size of our arrays which would cause a Subscript out of range error. We could have 41 students if we decided to use position 0 of each array.

```
10    DIM N$(40), T1(40), T2(40), T3(40), TAVG(40)
20    READ NSTUDS
30    IF NSTUDS <= 40 THEN GOTO 100
40    PRINT "I can only handle up to 40 students."
50    GOTO 350
100   FOR I = 1 TO NSTUDS
110      READ N$(I), T1(I), T2(I), T3(I)
120      LET TAVG = (T1(I) + T2(I) + T3(I))/3 0
130      NEXT I
140   PRINT "STUDENT     TEST 1    TEST 2    TEST 3"
150   FOR I = NSTUDS
160      PRINT N$(I),T1(I),T2(I),T3(I)
170      NEXT I
180   PRINT : PRINT "STUDENT     TEST AVG"
200   FOR I = 1 TO NSTUDS
210      PRINT N$(I),TAVG(I)
220      NEXT I
300   REM DATA SECTION
320   DATA 3,HULK,75,90,85
330   DATA GILLIGAN,35,33,54
340   DATA DOOGIE,100,100,103
350   END
```

This program will produce almost the same output as the program from the INPUT/OUTPUT section listed earlier. (We didn't format the table in columns -- PRINT USING) However, now we aren't limited to just 3 students We can have up to 40 (or 41) without having to use 40 different sets of variables.

GRAPHICAL REPRESENTATION OF STRING FUNCTIONS

The three string functions, LEFT$(A$,L), RIGHT$(A$,L) and MID$(A$,S,L) are used to make substrings out of existing strings.

In all three functions, L, the LENGTH, is the number of characters copied from the parent string to the substring. In MID$, S is the STARTING position.

LEFT$(A$,L) takes L characters off the left of the parent.

RIGHT$(A$,L) takes L characters off the right of the parent.

MID$(A$,S,L) takes L characters from the parent string starting from character number S.

Press return to see this in action.

[--Next Screen--]

Let A$ through I$ represent 9 pieces of main memory.

Let A$ = "CONESTOGA"	A$ =	CONESTOGA
Let B$ = LEFT$(A$,4)	B$ =	CONE
	C$ =	
	D$ =	
	E$ =	
	F$ =	
	G$ =	
	H$ =	

Press ENTER to continue.

[--As each command is displayed on the screen, the portion of the parent string A$ that is being used, flashes and the resulting substring, (B$), is displayed after the equal sign. Hitting ENTER causes the next string command to be displayed, followed by a flashing display of the corresponding portion of the parent string and the resulting substring. The final screen for this section is displayed on the next page.--]

Let A$ through I$ represent 9 pieces of main memory.

Let A$ = "CONESTOGA"	A$ = CONESTOGA
Let B$ = LEFT$(A$,4)	B$ = CONE
Let C$ = LEFT$(A$,3)	C$ = CON
Let D$ = RIGHT$(A$,1)	D$ = A
Let E$ = RIGHT$(A$,4)	E$ = TOGA
Let F$ = MID$(A$,3,4)	F$ = NEST
Let G$ = MID$(A$,6,2)	G$ = TO
Let H$ = MID$(A$,6,3)	H$ = TOG

Press ENTER to continue.

[--Next Screen--]

The LEN(A$) function returns a number equal to the number of characters in the string.

For example:

A$	LEN(A$)
A$ = "1234567890123456789012345678901234567890"	
B$ = "HELLO"	
C$ = "THIS IS A STRING"	
D$ = "MY NAME IS SUE, HOW DO YOU DO ?"	
E$ = "THE GREAT BALLOON BASH"	

Press ENTER to continue.

[--For each string listed, the user is given the opportunity to calculate its length. Subsequent and repeated strokes of the ENTER key cause the computed length to be displayed in the LEN(A$) column. The final screen display for this section is presented on the next page.--]

The LEN(A$) function returns a number equal to the number of characters in the string.

For example:

A$	LEN(A$)
A$ = "1234567890123456789012345678901234567890"	40
B$ = "HELLO"	5
C$ = "THIS IS A STRING"	16
D$ = "MY NAME IS SUE, HOW DO YOU DO ?"	31
E$ = "THE GREAT BALLOON BASH"	22

Press ENTER to continue.

[--Next Screen--]

One use of these functions is to separate a string into separate letters so they can be analyzed or printed in a different order.

The following routine can be used to print a word vertically:

```
100 REM WALL CLIMBER                    I            Output
110 READ A$
112 PRINT A$
120 FOR I = 1 TO LEN(A$)
130   B$ = MID$(A$,I,1)
140   PRINT B$
150   NEXT I
160 END
170 DATA MCQUAID
```

Press ENTER to continue.

[--The program execution begins by displaying A$. At each iteration of the FOR/NEXT loop, the single letter of A$ that is referenced flashes in concert with the vertical letter that is printed. The resulting output follows.--]

One use of these functions is to separate a string into separate letters so they can be analyzed or printed in a different order.

The following routine can be used to print a word vertically:

```
100 REM WALL CLIMBER                    I            Output
110 READ A$                             7            MCQUAID
112 PRINT A$                                         M
120 FOR I = 1 TO LEN(A$)                             C
130   B$ = MID$(A$,I,1)                              Q
140   PRINT B$                                       U
150   NEXT I                                         A
160 END                                              I
170 DATA MCQUAID                                     D
```

Lines 120, 130, and 150 of this routine are so useful they have a name, The Scanning Algorithm.

Press ENTER to continue

[--Next Screen--]

CONCATENATION is the operation which combines small strings into large ones.

In BASIC, concatenation is an operation rather than a function.

```
100 REM CONCATENATE                     A$ =
110 LET A$ = "EASTER"
120 LET B$ = "VACATION"                 B$ =
130 LET C$ = A$ + " " + B$
                                        C$ =
```

Press ENTER to continue.

[--As each of the strings, A$ and B$, are valued, they flash on the screen following their respective = signs. When the C$ statement is executed, each portion of the string is flashed as it is combined and displayed following the C$.--]

CONCATENATION is the operation which combines small strings into large ones.

In BASIC, concatenation is an operation rather than a function.

```
100 REM CONCATENATE                         A$ = EASTER
110 LET A$ = "EASTER"
120 LET B$ = "VACATION"                     B$ = VACATION
130 LET C$ = A$ + " " + B$
                                            C$ = EASTER VACATION
```

Press ENTER to continue.

[--Next Screen--]

Concatenation is often used together with the string functions to rearrange strings. Can you guess what this routine does?

```
100 REM ?
110 A$ = "DONALD TRUMP"                 A$ =
120 FOR I = LEN(A$) TO 1 STEP -1
130   B$ = MID$(A$,I,1)                 B$ =
140   C$ = C$ + B$
150   NEXT I                            C$ =
160 PRINT C$
170 END
```

Press ENTER to continue.

[--As each letter of A$ is accessed through the loop, it is flashed in B$ and appended to C$ producing the original string in reverse order. When I = 8, the screen flashes the letter L in A$, displays L at B$ and produces PMURT DL for C$ as seen below --]

```
100 REM ?
110 A$ = "DONALD TRUMP"                 A$ = DONALD TRUMP
120 FOR I = LEN(A$) TO 1 STEP -1
130   B$ = MID$(A$,I,1)                 B$ =
140   C$ = C$ + B$
150   NEXT I                            C$ = PMURT DL
160 PRINT C$
170 END
```

Press ENTER to continue.

[--The final display for the program produces the following results.--]

```
100 REM ?
110 A$ = "DONALD TRUMP"                          A$ = DONALD TRUMP
120 FOR I = LEN(A$) TO 1 STEP -1
130   B$ = MID$(A$,I,1)                          B$ = D
140   C$ = C$ + B$
150   NEXT I                                     C$ = PMURT DLANOD
160 PRINT C$
170 END
```

This routine makes a new string containing all the letters of the parent string in reverse order
What is your name spelled backwards?

Did you notice that lines 120, 130, and 150 are a version of the scanning algorithm?

Press ENTER to continue.

[--Next Screen--]

The last functions we will study are VAL(A$) and STR$(N).

Remember that all numbers stored in the computer's memory are converted into binary numbers before being stored in numeric variables. Characters, on the other hand, are stored as strings of ASCII codes.

The numeral characters, 0, 1, 2, etc can be stored in strings as ASCII codes but no arithmetic can be done on them while they are in that form

Press ENTER to continue.

[--Next Screen--]

If the leading characters in a string are numerals then VAL(A$) will give you a numeric variable equal to that number.
The conversion stops as soon as VAL finds a space or any other character it can not make into a number.
If the first character is not part of a number that VAL(A$) is 0.

Can you guess these before pressing ENTER?

```
VAL("76 TROMBONES")
VAL("SEVENTEEN YEARS OLD")
VAL("4 SCORE AND 7 YEARS AGO")
VAL("99.44% PURE")
VAL("-12 DEGREES")
VAL("-21.632.15")
VAL("-1.32578E+3 WOMBATS")
```

Press ENTER to continue.

[--As in the LEN screen, at each command statement, the system pauses allowing the student to think about the answer. Hitting ENTER displays the correct answer and positions to the next command and pauses. The final screen of answers is as follows:--]

```
VAL("76 TROMBONES")                   76
VAL("SEVENTEEN YEARS OLD")            0
VAL("4 SCORE AND 7 YEARS AGO")        4
VAL("99.44% PURE")                    99.44
VAL("-12 DEGREES")                    -12
VAL("-21.632.15")                     -21.632
VAL("-1.32578E+3 WOMBATS")            -1325.78
```

[--Next Screen--]

STR$(N) is the inverse function of VAL(A$). STR$(N) will take a number, stored in binary and turn it into a string, stored in ASCII codes. Why? - Well can you guess the one thing you can do with strings that you cannot do with numbers?

Press ENTER to continue.

Strings can be concatenated or chopped into substrings.
What does the following program do?

```
100 REM BAD MATH
110 LET A = 44
120 LET B = 26
130 LET A$ = STR$(A)
140 LET B$ = STR$(B)
150 :
160 LET C$ = A$ + B$
170 PRINT A "+" B "=" C$
```

Press ENTER to continue.

[--As each line of the program is executed, the value of the corresponding variable is displayed. After hitting ENTER once, the screen shows the following.--]

STR$(N) is the inverse function of VAL(A$). STR$(N) will take a number, stored in binary and turn it into a string, stored in ASCII codes. Why? - Well can you guess the one thing you can do with strings that you cannot do with numbers?

Strings can be concatenated or chopped into substrings
What does the following program do?

```
100 REM BAD MATH
110 LET A = 44                 A = 101100   (binary for 44)
120 LET B = 26                 B =  11010   (binary for 26)
130 LET A$ = STR$(A)           A$ = 20 34 34  (ASCII FOR  space 4 4)
140 LET B$ = STR$(B)           B$ = 20 32 36  (ASCII FOR  space 2 6)
150 :
160 LET C$ = A$ + B$           C$ = 20 34 34 20 32 36
170 PRINT A "+" B "=" C$       44 + 26 =  44 26
```

Press ENTER to continue.

[--After hitting ENTER 6 times, the screen is completed as above and an additional message is displayed --]

Of course the space between 44 and 26 does ruin the effect so let's add one more line to the routine

[--Program line 150 is inserted flashing. As the new sequence of commands is executed, changes to B$ and C$ are displayed with the movement of characters flashing and converging into the final format shown below --]

STR$(N) is the inverse function of VAL(A$). STR$(N) will take a number, stored in binary and turn it into a string, stored in ASCII codes Why? - Well can you guess the one thing you can do with strings that you cannot do with numbers?

Strings can be concatenated or chopped into substrings.
What does the following program do?

```
100 REM BAD MATH
110 LET A = 44               A = 101100    (binary for 44)
120 LET B = 26               B =  11010    (binary for 26)
130 LET A$ = STR$(A)         A$ = 20 34 34  (ASCII FOR  space 4 4)
140 LET B$ = STR$(B)         B$ = 20 32 36  (ASCII FOR  space 2 6)
150 LET B$ = MID$(A$,2,2)    B$ = 32 36
160 LET C$ = A$ + B$         C$ = 20 34 34 32 36
170 PRINT A "+" B "=" C$     44 + 26 =  4426
```

Press ENTER to continue

[--The session now ends by returning to the methods menu.--]

Appendix H

SAMPLE QUIZ QUESTIONS

1. When a RESTORE statement is executed, the data pointer is moved so that it points to
   A) the first DATA statement following the RESTORE.
   B) the first data value in the last DATA statement read just prior to executing the RESTORE.
   C) the first DATA statement in the entire program.

2, Which symbol represents a digit in a numeric field specifier?
   A) *   B) %   C) #   D) !   E) None of these

3. What output is produced by the following statement?

```
10  PRINT USING "##,###.##-";-234.567
```

   A) -$ 234 56   B) 234.56-
   C) -234.57   D) 234.57-   E) SYNTAX ERROR

4 What output is produced by the following routine?

```
100  READ A$, B$, C$
110  PRINT USING "!", A$, B$, C$
120  DATA National, Football, League
```

   A) N F L
   B) NFL
   C) NATIONAL FOOTBALL LEAGUE
   D) National! Football! League!

5 What will be the output from the following program?

```
10  DIM X(5), Y(5), Z(5)
20  READ N
30  FOR I = 1 TO N
40     READ X(I), Y(I)
50     LET Z(I) = X(I) + Y(I)
60     NEXT I
70  FOR I = 1 TO N
80     PRINT Z(I)
90     NEXT I
100 DATA 2,3,4,8,9
110 END
```

   A) 7
      17
   B) 5
      12
   C) 3   4   8   9   5
   D) 2   3   4   8   9

6. What is wrong with the following program?

```
100  FOR A = 9 TO 12
110     READ M(A)
120     PRINT M(A);
130     NEXT A
140  DATA 7,3,5,2,9,1,-3,-2
150  END
```

A) The FOR loop can't start with 9
B) An OUT OF DATA Error will occur
C) There is no DIMension statement.
D) All of the above.

7 What is the output of the following program?

```
100  DIM N(10)
110  FOR I = 1 TO 10
120     READ N(I)
130     NEXT I
140  DATA 23, 5, 8, 32, 16, 14, 21, 26, 4, 15
150  PRINT N(1), N(3), N(1 + 3)
```

A) 23 8 32   B) 23 8 31
C) 8 31 23   D) ?BS ERROR

8 Which functions can be used to generate SUBSTRINGS?
A) LEFT$, RIGHT$
B) LEFT$, RIGHT$, MID$
C) VAL, LEN
D) LEFT$, RIGHT$, MID$, STR$
E) None of the Above

9 What is the output of the following routine?

```
100  LET A$ = "CAMPGROUND NUMBER 7"
110  PRINT LEN(A$)
```

A) CAMP   B) GROUND
C) 19   D) 7
E) NUMBER

10. What is the output of the following routine?

```
100  LET A$ = "CAMPGROUND NUMBER 7"
110  PRINT MID$(A$,2,3)
```

A) CAM   B) BER
C) AM   D) AMP
E) 0

Appendix I

Myers-Briggs Indicators and
Keirsey Temperament Types

Student	Introvert/ Extrovert	Intuitive/ Sensing	Thinking/ Feeling	Judging/ Perceiving	Temperament Type
1	E	N	F	P	NF
2	E	N	F	J	NF
3	I	N	F	P	NF
4	I	S	T	P	SP
5	I	S	T	P	SP
6	I	N	F	P	NF
7	E	S	F	P	SP
8	E	N	F	P	NF
9	I	S	T	P	SP
10	E	N	F	J	NF
11	I	S	T	P	SP
12	I	N	F	P	NF
13	E	N	F	P	NF
14	E	S	T	P	SP
15	E	N	F	P	NF
16	E	N	F	P	NF
17	I	N	F	P	NF
18	I	S	T	P	SP
19	I	S	T	P	SP
20	I	N	F	J	NF
21	E	N	F	P	NF
22	I	S	F	P	SP
23	I	N	F	P	NF

Appendix I

Myers-Briggs Indicators and
Keirsey Temperament Types

Student	Introvert/ Extrovert	Intuitive/ Sensing	Thinking/ Feeling	Judging/ Perceiving	Temperament Type
24	I	S	T	P	SP
25	I	S	F	P	SP
26	I	S	T	J	SJ
27	E	N	T	J	NT
28	I	N	T	P	NT
29	I	N	T	J	NT
30	E	N	T	P	NT
31	I	N	F	P	NF
32	I	S	T	P	SP
33	E	S	T	P	SP
34	I	N	F	J	NF

DEVELOPERS

Material	Introvert/ Extrovert	Intuitive/ Sensing	Thinking/ Feeling	Judging/ Perceiving	Temperament Type
Text	I	S	T	J	SJ
Graphics	I	N	T	J	NT
Code Eg	I	N	F	P	NF

Appendix J

Computer Use Survery (Experience)

Student	Age	Access	Use	Type	InSchool	Use	Type	Lang.	Prior
1	17	N			N			N	N
2	18	N			N			N	N
3	17	Y	1	1	N			N	N
4	17	N			Y	1	2	N	Y
5	17	Y	1	1-4	N			N	Y
6	17	Y	1	1	N			N	N
7	18	N			Y	1	3,4	N	N
8	18	N			N			N	Y
9	17	Y	5	2-5	N			N	N
10	18	N			N			N	N
11	18	N			Y	1	2-4	N	N
12	18	N			Y	1	1,2	N	N
13	17	N			N			N	Y
14	17	Y	4	2-4	N			N	N
15	17	N			N			N	N
16	17	Y	2	1-4	N			N	Y
17	17	N			N			N	N
18	17	Y	<1	1,4	N			N	N
19	17	N			N			N	N
20	17	Y	2	1,4	N			N	N
21	18	Y	10	1-4	N			N	N
22	17	Y	<1	1,2,4	Y	<1	2,4	N	N
23	17	N			N			N	N

Appendix J

Computer Use Survery (Experience)

Student	Age	Access	Use	Type	InSchool	Use	Type	Lang.	Prior
24	16	Y	<1	1,4	N			N	N
25	18	Y	1	1-4	N			N	N
26	18	Y	2	1,4	Y	1	2	N	N
27	17	Y	<1	1	N			Y	N
28	18	Y	2	2,3,4	N			N	Y
29	17	Y	3	1,3-5	N			N	Y
30	17	Y	20	1-5	N			Y	Y
31	18	N			N			N	Y
32	18	N			N			N	N
33	18	Y	1	1,5	N			N	N
34	18	N			N			N	N

The use survey was used to differentiate between Computer User and Non-User with the following point system.

Question	Answer	Points
2.	Yes	1
2A.	<= 1	0
	1 - 4	1
	>5	2
2B.	Games Only	0
	Any other	1
3	Yes	1
3A.	<= 1	0
	1 - 4	1
	>5	2
3B.	Games Only	0
	Any other	1
4.	Yes	1
5.	Yes	1

The point spread was from 0 - 5. A student with 0 or 1 points is considered a non-user Two or more points indicates a computer user.

Appendix K

Student Grades

Student	Quiz 1	Quiz 2	Quiz 3	Quiz Avg.	Averages Sem. 1	Sem. 2	Final
1	4/20	4/15	3/15	22	70	77	74
2	8/20	4/15	2/15	28	77	78	78
3	11/20	4/15	4/15	38	87	86	87
4	6/20	2/15	7/15	30	80	82	81
5	8/20	5/15	5/15	36	80	74	77
6	17/20	10/15	12/15	78	99	94	97
7	2/20	4/15	7/15	26	81	76	79
8	5/20	8/15	5/15	36	83	73	78
9	14/20	8/15	8/15	60	94	91	93
10	3/20	3/15	7/15	26	81	80	81
11	8/20	5/15	7/15	40	85	86	86
12	14/20	9/15	12/15	70	97	100	99
13	4/20	4/15	0/15	16	78	71	75
14	11/20	6/15	6/15	46	83	82	83
15	14/20	5/15	10/15	58	86	85	86
16	9/20	5/15	5/15	38	85	81	83
17	5/20	7/15	12/15	48	87	87	87
18	8/20	7/15	3/15	36	84	85	85
19	12/20	6/15	8/15	46	90	84	87
20	14/20	9/15	11/15	68	95	91	93
21	7/20	3/15	6/15	32	74	83	79
22	15/20	11/15	11/15	74	97	100	99
23	16/20	7/15	12/15	70	92	88	90

Appendix K

Student Grades

Student	Quiz 1	Quiz 2	Quiz 3	Quiz Avg.	Sem. 1	Averages Sem. 2	Final
24	13/20	8/15	9/15	60	91	87	89
25	11/20	7/15	8/15	52	93	86	90
26	9/20	4/15	1/15	28	70	70	70
27	9/20	4/15	5/15	36	82	82	82
28	18/20	11/15	15/15	88	97	99	98
29	9/20	4/15	4/15	34	87	82	85
30	3/20	7/15	4/15	28	80	80	80
31	4/20	6/15	3/15	26	71	67	69
32	7/20	6/15	5/15	36	77	79	78
33	12/20	3/15	5/15	40	89	90	90
34	5/20	6/15	7/15	36	81	80	81
Class Avg.	9/20	6/15	7/15	44	84.97	83.53	84.53

Appendix L

INPUT/OUTPUT Unit Format Choices

Student	Text	Definitions	Graphics	Code Eg.	Total
1	4	6	2 *	2 x	14
2	1 *	2	1	1 x	5
3	2 *x	1	1	2	6
4	2 x	2	3 *	2	9
5	4 *x	4	4	3	15
6	1	1 x	1 *	2	5
7	4 *x	3	3	2	12
8	1	4 x	2 *	3	10
9	4	4 *x	2	4	14
10	3	2	3 *	7 x	15
11	2 *	1	1	4 x	8
12	1 *	1	2 x	2	6
13	0	2 x	3 *	2	7
14	1 *	1	3 x	1	6
15	2 *	3	3	2 x	10
16	1 *	0	1	1 x	3
17	2 *	2 x	1	1	6
18	1 *	1	2 x	1	5
19	1	0	1 x	1 *	3
20	1	1	1 *	1 x	4
21	4 *	3	3 x	6	16
22	2	1 *	2 x	1	6

* First method chosen
x Last method chosen

Appendix L

INPUT/OUTPUT Unit Format Choices

Student	Text	Definitions	Graphics	Code Eg.	Total
23	0	0	2 *x	0	2
24	1 *	2 x	1	1	5
25	2	2 x	0	2 *	6
26	1 *	4 x	2	2	9
27	3 *	3 x	3	2	11
28	3 *	0	6 x	0	9
29	2 *x	2	1	2	7
30	2 *	1	2	1 x	6
31	1 *	3 x	1	1	6
32	1 *	0	2	1 x	4
33	5 *	4	4	2 x	15
34	1 *	1	2	1 x	5

* First method chosen
x Last method chosen

Appendix L

ARRAYS Unit Format Choices

Student	Text	Definitions	Graphics	Code Eg.	Total
1	7	10 *x	7	1	25
2	1 x	1 *	1	1	4
3	1 *	3	1	2 x	7
4	2	4 x	5 *	5	16
5	7	5	6 x	7 *	25
6	1 x	2	3 *	2	8
7	5 *x	2	3	0	10
8	1	1 *	2 x	3	7
9	3 *	4	4 x	6	17
10	0	1 x	2 *	1	4
11	4 x	0	1	4 *	9
12	1	1	2 *	2 x	6
13	1 x	2 *	6	5	14
14	4 *	4	5 x	0	13
15	6 *	6	5 x	6	23
16	2	3 *	2 x	5	12
17	4 *x	3	3	2	12
18	2	6 *x	3	2	13
19	3 *	1	2 x	1	7
20	3	2	4 *x	2	11
21	7 *x	2	4	3	16
22	1 *	1	2 x	1	5

* First method chosen
x Last method chosen

Appendix L

ARRAYS Unit Format Choices

Student	Text	Definitions	Graphics	Code Eg	Total
23	0	0	2 *	2 x	4
24	2	3 *x	2	2	9
25	3	5	0	2 *x	10
26	2 *	0	2	2 x	6
27	2 *	3	1	3 x	9
28	1 x	0	2 *	0	3
29	2 *	4 x	2	1	9
30	1 *	2	3	2 x	8
31	0	1	3 *	3 x	7
32	0	1 *x	0	0	1
33	5 *	4	6	1 x	16
34	0	0	2 *	1 x	3

* First method chosen
x Last method chosen

Appendix L

STRING Functions Unit Format Choices

Student	Text	Definitions	Graphics	Code Eg	Total
1	2 *x	1	1	1	5
2	2 *	0	2 x	0	4
3	6 *	3	2 x	1	12
4	6 *	4	4	3 x	17
5	3 *	0	2 x	2	7
6	1	1 x	4 *	1	7
7	4 *	9	2	4 x	19
8	1 *	1	1	2 x	5
9	7 *	4 x	2	4	17
10	0	2	2 *x	2	6
11	8 *	8	5 x	2	23
12	1 *	1	1	2 x	5
13	0	0	3 *	3 x	6
14	0	2 *x	2	0	4
15	1 *	2	1	1 x	5
16	0	0	1 *	1 x	2
17	4 *x	2	2	1	9
18	1 *	1	1	2 x	5
19	2 *	3	2	2 x	9
20	0	0	6 *x	0	6
21	2 *	2 x	2	2	8
22	1 *	0	2	2 x	5

* First method chosen
x Last method chosen

Appendix L

STRING Functions Unit Format Choices

Student	Text	Definitions	Graphics	Code Eg.	Total
23	1	0	2 *x	2	5
24	3 *	3	2	1 x	9
25	0	3 *	0	2 x	5
26	3 *	1	1	2 x	7
27	3 *	2	3 x	1	9
28	0	0	5 *x	0	5
29	2 *	2	2	3 x	9
30	1 *	1	2	1 x	5
31	1	2 *	6 x	2	11
32	0	0	1 *	1 x	2
33	1 *	0	0	2 x	3
34	0	0	1 *	1 x	2

* First method chosen
x Last method chosen

Appendix M

IO Format Choices by Temperament Type

Type	Student	Text	Defns.	Graphics	Code Eg.	Total	Quiz Score
NF	1	4	6	2 *	2 x	14	4/20
	2	1 *	2	1	1 x	5	8/20
	3	2 *x	1	1	2	6	11/20
	6	1	1 x	1 *	2	5	17/20
	8	1	4 x	2 *	3	10	5/20
	10	3	2	3 *	7 x	15	3/20
	12	1 *	1	2 x	2	6	14/20
	13	0	2 x	3 *	2	7	4/20
	15	2 *	3	3	2 x	10	14/20
	16	1 *	0	1	1 x	3	9/20
	17	2 *	2 x	1	1	6	5/20
	20	1	1	1 *	1 x	4	14/20
	21	4 *	3	3 x	6	16	7/20
	23	0	0	2 *x	0	2	16/20
	31	1 *	3 x	1	1	6	4/20
	34	1 *	1	2	1 x	5	5/20
NT	27	3 *	3 x	3	2	11	9/20
	28	3 *	0	6 x	0	9	18/20
	29	2 *x	2	1	2	7	9/20
	30	2 *	1	2	1 x	6	3/20
SP	4	2 x	2	3 *	2	9	6/20
	5	4 *x	4	4	3	15	8/20

* First method chosen
x Last method chosen

Appendix M

IO Format Choices by Temperament Type

Type	Student	Text	Defns.	Graphics	Code Eg.	Total	Quiz Score
SP	7	4 *x	3	3	2	12	2/20
	9	4	4 *x	2	4	14	14/20
	11	2 *	1	1	4 x	8	8/20
	14	1 *	1	3	2 x	6	11/20
	18	1 *	1	2 x	1	5	8/20
	19	1	0	1 x	1 *	3	12/20
	22	2	1 *	2 x	1	6	15/20
	24	1 *	2 x	1	1	5	13/20
	25	2	2 x	0	2 *	6	11/20
	32	1 *	0	2	1 x	4	7/20
	33	5 *	4	4	2 x	15	12/20
SJ	26	1 *	4 x	2	2	9	9/20

* First method chosen
x Last method chosen

Appendix M

ARRAY Format Choices by Temperament Type

Type	Student	Text	Defns.	Graphics	Code Eg.	Total	Quiz Score
NF	1	7	10 *x	7	1	25	4/15
	2	1 x	1 *	1	1	4	4/15
	3	1 *	3	1	2 x	7	4/15
	6	1 x	2	3 *	2	8	10/15
	8	1	1 *	2 x	3	7	8/15
	10	0	1 x	2 *	1	4	3/15
	12	1	1	2 *	2 x	6	9/15
	13	1 x	2 *	6	5	14	4/15
	15	6 *	6	5 x	6	23	5/15
	16	2	3 *	2 x	5	12	5/15
	17	4 *x	3	3	2	12	7/15
	20	3	2	4 *x	2	11	9/15
	21	7 *x	2	4	3	16	3/15
	23	0	0	2 *	2 x	4	7/15
	31	0	1	3 *	3 x	7	6/15
	34	0	0	2 *	1 x	3	6/15
NT	27	2 *	3	1	3 x	9	4/15
	28	1 x	0	2 *	0	3	11/15
	29	2 *	4 x	2	1	9	4/15
	30	1 *	2	3	2 x	8	7/15
SP	4	2	4 x	5 *	5	16	2/15
	5	7	5	6 x	7 *	25	5/15

* First method chosen
x Last method chosen

Appendix M

ARRAY Format Choices by Temperament Type

Type	Student	Text	Defns.	Graphics	Code Eg.	Total	Quiz Score
SP	7	5 *x	2	3	0	10	4/15
	9	3 *	4	4 x	6	17	8/15
	11	4 x	0	1	4 *	9	5/15
	14	4 *	4	5 x	0	13	6/15
	18	2	6 *x	3	2	13	7/15
	19	3 *	1	2 x	1	7	6/15
	22	1 *	1	2 x	1	5	11/15
	24	2	3 *x	2	2	9	8/15
	25	3	5	0	2 *x	10	7/15
	32	0	1 *x	0	0	1	6/15
	33	5 *	4	6	1 x	16	3/15
SJ	26	2 *	0	2	2 x	6	4/15

* First method chosen
x Last method chosen

Appendix M

STRING Functions Format Choices by Temperament Type

Type	Student	Text	Defns.	Graphics	Code Eg.	Total	Quiz Score
NF	1	2 *x	1	1	1	5	3/15
	2	2 *	0	2 x	0	4	2/15
	3	6 *	3	2 x	1	12	4/15
	6	1	1 x	4 *	1	7	12/15
	8	1 *	1	1	2 x	5	5/15
	10	0	2	2 *x	2	6	7/15
	12	1 *	1	1	2 x	5	12/15
	13	0	0 x	3 *	3 x	6	0/15
	15	1 *	2	1	1 x	5	10/15
	16	0	0	1 *	1 x	2	5/15
	17	4 *x	2	2	1	9	12/15
	20	0	0	6 *x	0	6	11/15
	21	2 *	2 x	2	2	8	6/15
	23	1	0	2 *x	2	5	12/15
	31	1	2 *	6 x	2	11	3/15
	34	0	0	1 *	1 x	2	7/15
NT	27	3 *	2 x	3 x	1	9	5/15
	28	0	0	5 *x	0	5	15/15
	29	2 *	2	2	3 x	9	4/15
	30	1 *	1	2	1 x	5	4/15
SP	4	6 *	4	4	3 x	17	7/15
	5	3 *	0	2 x	2	7	5/15

* First method chosen
x Last method chosen

Appendix M

STRING Functions Format Choices by Temperament Type

Type	Student	Text	Defns.	Graphics	Code Eg.	Total	Quiz Score
SP	7	4 *	9	2	4 x	19	7/15
	9	7 *	4 x	2	4	17	8/15
	11	8 *	8	5 x	2	23	7/15
	14	0	2 *x	2	0	4	6/15
	18	1 *	1	1	2 x	5	3/15
	19	2 *	3	2	2 x	9	8/15
	22	1 *	0	2	2 x	5	11/15
	24	3 *	3	2	1 x	9	9/15
	25	0	3 *x	0	2 x	5	8/15
	32	0	0	1 *	1 x	2	5/15
	33	1 *	0	0	2 x	3	5/15
SJ	26	3 *	1	1	2 x	7	1/15

* First method chosen
x Last method chosen

Appendix N

Combined Format Choices by Temperament Type

Type	Student	Text	Defns.	Graphics	Code Eg.	Total	Quiz Score
NF	1	4	6	2 *	2 x	14	20
	1	7	10 *x	7	1	25	26.7
	1	2 *x	1	1	1	5	20
	2	1 *	2	1	1 x	5	40
	2	1 x	1 *	1	1	4	26.7
	2	2 *	0	2 x	0	4	13.3
	3	2 *x	1	1	2	6	55
	3	1 *	3	1	2 x	7	26.7
	3	6 *	3	2 x	1	12	26.7
	6	1	1 x	1 *	2	5	85
	6	1 x	2	3 *	2	8	66.7
	6	1	1 x	4 *	1	7	80
	8	1	4 x	2 *	3	10	25
	8	1	1 *	2 x	3	7	53.3
	8	1 *	1	1	2 x	5	33.3
	10	3	2	3 *	7 x	15	15
	10	0	1 x	2 *	1	4	20
	10	0	2	2 *x	2	6	46.7
	12	1 *	1	2 x	2	6	70
	12	1	1	2 *	2 x	6	60
	12	1 *	1	1	2 x	5	80
	13	0	2 x	3 *	2	7	20
	13	1 x	2 *	6	5	14	26.7
	13	0	0 x	3 *	3 x	6	0
	15	2 *	3	3	2 x	10	70
	15	6 *	6	5 x	6	23	33.3
	15	1 *	2	1	1 x	5	66.7
	16	1 *	0	1	1 x	3	45
	16	2	3 *	2 x	5	12	33.3
	16	0	0	1 *	1 x	2	33.3
	17	2 *	2 x	1	1	6	25
	17	4 *x	3	3	2	12	46.7
	17	4 *x	2	2	1	9	80

* First method chosen
x Last method chosen

Appendix N

Combined Format Choices by Temperament Type

Type	Student	Text	Defns.	Graphics	Code Eg.	Total	Quiz Score
NF	20	1	1	1 *	1 x	4	70
	20	3	2	4 *x	2	11	60
	20	0	0	6 *x	0	6	73.3
	21	4 *	3	3 x	6	16	35
	21	7 *x	2	4	3	16	20
	21	2 *	2 x	2	2	8	40
	23	0	0	2 *x	0	2	80
	23	0	0	2 *	2 x	4	46.7
	23	1	0	2 *x	2	5	80
	31	1 *	3 x	1	1	6	20
	31	0	1	3 *	3 x	7	40
	31	1	2 *	6 x	2	11	20
	34	1 *	1	2	1 x	5	25
	34	0	0	2 *	1 x	3	40
	34	0	0	1 *	1 x	2	46.7
NT	27	3 *	3 x	3	2	11	45
	27	2 *	3	1	3 x	9	26.7
	27	3 *	2 x	3 x	1	9	33.3
	28	3 *	0	6 x	0	9	90
	28	1 x	0	2 *	0	3	73.3
	28	0	0	5 *x	0	5	100
	29	2 *x	2	1	2	7	45
	29	2 *	4 x	2	1	9	26.7
	29	2 *	2	2	3 x	9	26.7
	30	2 *	1	2	1 x	6	15
	30	1 *	2	3	2 x	8	46.7
	30	1 *	1	2	1 x	5	26.7
SP	4	2 x	2	3 *	2	9	30
	4	2	4 x	5 *	5	16	13.3
	4	6 *	4	4	3 x	17	46.7
	5	4 *x	4	4	3	15	40
	5	7	5	6 x	7 *	25	33.3
	5	3 *	0	2 x	2	7	33.3

* First method chosen
x Last method chosen

Appendix N

Combined Format Choices by Temperament Type

Type	Student	Text	Defns.	Graphics	Code Eg.	Total	Quiz Score
SP	7	4 *x	3	3	2	12	10
	7	5 *x	2	3	0	10	26.7
	7	4 *	9	2	4 x	19	46.7
	9	4	4 *x	2	4	14	70
	9	3 *	4	4 x	6	17	53.3
	9	7 *	4 x	2	4	17	53.3
	11	2 *	1	1	4 x	8	40
	11	4 x	0	1	4 *	9	33.3
	11	8 *	8	5 x	2	23	46.7
	14	1 *	1	3	2 x	6	55
	14	4 *	4	5 x	0	13	40
	14	0	2 *x	2	0	4	40
	18	1 *	1	2 x	1	5	40
	18	2	6 *x	3	2	13	46.7
	18	1 *	1	1	2 x	5	20
	19	1	0	1 x	1 *	3	60
	19	3 *	1	2 x	1	7	40
	19	2 *	3	2	2 x	9	53 3
	22	2	1 *	2 x	1	6	75
	22	1 *	1	2 x	1	5	73.3
	22	1 *	0	2	2 x	5	73.3
	24	1 *	2 x	1	1	5	65
	24	2	3 *x	2	2	9	53.3
	24	3 *	3	2	1 x	9	60
	25	2	2 x	0	2 *	6	55
	25	3	5	0	2 *x	10	46.7
	25	0	3 *x	0	2 x	5	53.3
	32	1 *	0	2	1 x	4	35
	32	0	1 *x	0	0	1	40
	32	0	0	1 *	1 x	2	33.3
	33	5 *	4	4	2 x	15	60
	33	5 *	4	6	1 x	16	20
	33	1 *	0	0	2 x	3	33.3
SJ	26	1 *	4 x	2	2	9	45
	26	2 *	0	2	2 x	6	26 7
	26	3 *	1	1	2 x	7	6.7

Appendix O

Post-instruction Helpfulness Survey

	CAI Project				Future Lessons		
Student	Text	Defns.	Graphics	Code Eg.	Text	Computer	Both
1	9	9	2	3	5	5	10
2	1	1	1	1	10	1	10
3	5	5	2	7	9	1	9
4	5	8	1	4	5	1	7
5	3	6	2	9	4	4	8
6	5	5	6	6	6	4	8
7	10	7	1	6	10	4	8
8	3	1	10	9	5	1	10
9	5	7	8	2	10	2	5
10	1	2	8	10	5	1	10
11	6	4	7	8	7	6	10
12	7	3	5	5	8	3	10
13	3	1	5	7	5	5	8
14	1	3	10	5	8	3	10
15	5	5	10	10	8	2	10
16	5	3	6	4	4	3	7
17	9	6	2	7	7	3	8
18	5	5	7	7	8	7	9
19	8	7	1	5	9	1	5
20	5	4	7	6	8	7	9
21	3	1	10	5	7	1	4
22	5	7	10	10	7	6	10

SCALE: 10 ==> Very Helpful to me
1 ==> Useless to me

Appendix O

Post-instruction Helpfulness Survey

Student	CAI Project				Future Lessons		
	Text	Defns.	Graphics	Code Eg.	Text	Computer	Both
23	5	2	10	9	3	6	10
24	7	7	7	6	8	4	10
25	5	9	1	9	7	5	8
26	7	5	6	3	5	5	8
27	4	4	8	9	3	6	9
28	6	5	10	5	4	10	10
29	2	4	10	9	2	5	9
30	4	6	9	2	8	3	10
31	4	7	2	3	6	5	1
32	4	5	1	3	8	5	10
33	6	2	10	5	10	3	5
34	3	6	10	9	10	2	9

SCALE: 10 ==> Very Helpful to me.
1 ==> Useless to me.

Appendix P

Subjective Criteria Plus

Student	Class Group	User/Non-user	Vocal/Non-vocal	Game player/ Not game player
1	A	N	N	N
2	A	N	N	N
3	A	U	N	G
4	A	U	V	N
5	A	U	N	G
6	A	U	N	G
7	A	U	N	N
8	A	U *	V	G *
9	A	U	V	N
10	A	N	V	N
11	A	U	V	N
12	A	U	N	G
13	A	N	V	N
14	A	U	V	N
15	B	N	V	G
16	B	U	V	G
17	B	N	N	N
18	B	U	N	G
19	B	N	N	N
20	B	U	N	G
21	B	U	V	G
22	B	U	N	G

* Data Point modified due to observation of actual behavior

Appendix P

Subjective Criteria Plus

Student	Class Group	User/Non-user	Vocal/Non-vocal	Game player/ Not game player
23	B	N	N	N
24	B	U	N	G
25	B	U	V	G
26	B	U	V	G
27	B	U	V	G
28	B	U	N	N
29	B	U	N	G
30	B	U	N	G
31	B	N	N	N
32	A	N	V	N
33	A	U	N	G
34	A	N	V	N

BIBLIOGRAPHY

Atkinson, Richard and H. A. Wilson, (eds.) Computer Assisted Instruction: A Book of Readings, Academic Press, New York, 1969.

Benbasat, Izak, Dexter, Albert S., and Paul S Masulis, "An Experimental Study of the Human/Computer Interface", Communications of the Association for Computing Machinery, 24(11):752-762, 1981.

Boden, Margaret A., Artificial Intelligence in Psychology, MIT Press, Cambridge, Massachusetts, 1989.

Bork, Alfred C., Learning with Computers, Digital Equipment Corp., Bedford, Massachusetts, 1981.

Brownsword, Alan, It Takes All Types, Baytree Publication Company, 1987.

Chambers, Jack A., and Jerry W. Sprecher, CAI - Its Use in the Classroom, Prentice-Hall Inc., Englewood Cliffs, New Jersey, 1983.

Clancey, William J., Knowledge-Based Tutoring: The GUIDON Program, MIT Press, Cambridge, Massachusetts, 1987.

Consulting Psychologists Press, Inc., Myers-Briggs Type Indicator Form G - Self Scorable; Katharine C. Briggs, Isabel Briggs Myers, Palo Alto, California, 1987.

Diceman, Scott, "Impulsivity and Perception: Individual Differences in the Processing of the Local and Global Dimensions of Stimuli", Journal of Personality and Social Psychology, 48(1):133-149, 1985.

Hickey, Albert E , Research Guidelines for CAI. Albert E. Hickey Associates, New York, 1974.

Hoffman, Jeffrey L. and Marianne Betkowski, "A Summary of Myers-Briggs Type Indicator Research Applications in Education". Research in Psychological Types, 3:3-41, 1981.

Holtzman, Wayne H., (ed.), Computer-Assisted Instruction, Testing and Guidance, Harper and Row Publishers, New York, New York, 1970.

Kearsley, Greg P , Artificial Intelligence and Instruction: Applications and Methods, Addison-Wesley Publishing Co., Reading, Massachusetts, 1987.

Kearsley, Greg P., Beverly Hunter and Robert J Seidel, "Two Decades of Computer Based Instruction Projects: What Have We Learned?", T.H.E. Journal, 10(4):88-96, 1983.

Keirsey, D. and Bates, M., Please Understand Me: An Essay on Temperament Styles, Promethean Books, Inc., California, 1978.

Lambert, Kathleen, The Relationship Between Computer Interaction and Individual User Characteristics, Thesis, RIT, Rochester, New York 1988.

Lawler, Robert W., and Masoud Yazdani, (eds.) AI and Education: Learning Environments and Tutoring Systems, Ablex Publishing, Norwood, New Jersey, 1987.

Lawrence, Gordon, People Types and Tiger Stripes, Center for Applications of Psychological Type, Inc., Gainesville, Florida, 1979

Martin, Chris, Personal Interview, Martha Brown Jr. High, Fairport, New York, May, 1989.

Mason, Richard O. and Ian I. Mitroff, "A Program for Research on Management Information Systems", Management Science, 19(5):475-487, 1973.

Myers, Isabel B. and Peter B. Myers, Gifts Differing, Consulting Psychologists Press, Inc., Palo Alto, California, 1980.

Papert, Seymour, Mindstorms: Children, Computers and Powerful Ideas, Basic Books, Inc., New York, 1980.

Rich, Elaine, "Users are Individuals: Individualizing User Models", International Journal of Man-Machine Studies, 18:199-214, 1983.

Schank, Roger C., On Language, Learning and the Cognitive Computer: Artificial Intelligence, Addison-Wesley Publishing Company, Inc., Reading, Massachusetts, 1984.

Self, John (ed.), Artificial Intelligence and Human Learning (ICAI), Chapman and Hall Computing, New York, New York, 1988.

Skinner, B. F., The Technology of Teaching, Appleton-Century-Crofts, New York, New York, 1968.

Sleeman, D. and J. S. Brown, (eds.), Intelligent Tutoring Systems, Academic Press Inc., New York, New York, 1982

VanDerVeer, Garrett C., Michael J. Tauber, Yvonne Waerns and Bert VanMuylwijk, "On the Interaction Between Systems and User Characteristics", Behavior and Information Technology, 4(4):289-308, 1985

Webster's New Collegiate Dictionary, G & C Merriam Company, Springfield, Massachusetts, 1976.

Wenger, Etienne, Artificial Intelligence and Tutoring Systems, Morgan Kaufman Publishers, Inc., Los Altos, California, 1987.